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# Checkout and Launch Control System (CLCS) System Level Specification



Version 6.5

Prepared By:

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# Checkout and Launch Control System (CLCS)

# System Level Specification

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# 1. INTRODUCTION

## 1.1 SCOPE

This document identifies the system level requirements that are the basis for the development of the Checkout and Launch Control System (CLCS). It contains requirements for the Real-Time Processing System (RTPS), Shuttle Data Center (SDC), Simulation System (SIM), and the Business and Information Network (BIN).

## 1.2 SYSTEM OVERVIEW

The CLCS is composed of the RTPS, the SDC, the SIM, and the BIN. The RTPS provides the capability to monitor and control the elements of the current Space Shuttle Flight Vehicle and Ground Support Equipment (GSE). The SDC is the repository for the Shuttle Launch Processing Test Data and provides the capability to build Test Packages for configuration of the RTPS. The capability to debug and certify RTPS software and to aid in the training of checkout and launch personnel is provided by the SIM. The BIN provides RTPS workstation connectivity and access to non-RTPS applications and data. CLCS provides support to the Space Shuttle Program into the 21st Century and a basic infrastructure upon which to base future design projects such as the Orbiter Upgrades and X-33/RLV.

The CLCS replaces the current Launch Processing System (LPS) with state-of-the-art Commercial Off the Shelf (COTS) based technology. Where task requirements can be met safely by COTS software products, the COTS software is utilized instead of developing custom applications. Any custom software that is developed is written in high level languages which have demonstrated a high degree of portability between platforms. COTS hardware is also utilized where possible in the CLCS. This strategy provides a reliable system that is modular, expandable, and extensible. It is based on open hardware and software standards, easily incorporates new technology and user developed applications, and provides inherent user interface improvements.

## 1.3 RELATED DOCUMENTS

| | | |
|---|---|---|
| CP09IT0916 | Launch Processing System Checkout, Control and Monitor Subsystem<br>Hardware Interface Module Assembly | December 1975 |
| ICD-2-0A003 | Flight Vehicle/LPS Computational Systems Interfaces, Rev. J | November 1994 |
| ICD-2-19001 | Shuttle Orbiter/Cargo Standard Interfaces, Rev. K | October 1995 |
| IRIG-200-95 | Inter-Range Timing Format | July 1995 |
| KSC-GP-792 | Timing Signal Formats | February 1972 |
| KSCL-1143-0463 | SCAN Design Specifications | February 1997 |
| SS-P-0002-140T | Space Shuttle Computer Program Development Specifications (CPDS)<br>SS Downlist/Uplink Software Requirements | October 1995 |
| SS-P-0002-150N | Space Shuttle Computer Program Development Specifications<br>SSL LDB Software Interface Requirements<br>Data Bank Services Requirements Specification | March 1996 |
| 83K001102 | HIM-II Detailed Design Document | September 1994 |

## 1.4 DOCUMENT OVERVIEW

This document is identified as the CLCS System Level Specification (SLS). The document is organized into

**Note:** Placeholder. Fill this in before final publication.

## 1.5 DOCUMENT CONVENTIONS

The term "shall" is used in this document to indicate that the sentence in which it is used is a requirement levied on one or more products in the CLCS. Conventional MIL-STD terminology is used for products; definitions of many of which can be found in the glossary. Each section of the document normally begins with a description of the items that are discussed within the section. In many cases, the term "must" is used in the description paragraphs to indicate functions that are needed in the CLCS and should not be construed as requirements on the

CLCS.  A “Rationale” section is optionally provided for further explanation regarding one or more requirements. These rationale paragraphs also do not impose requirements on the CLCS.

In requirements statements, the term CLCS is used when the requirement may be satisfied by Configuration Items (CIs) in one or more of the CLCS Major Subsystems.  When a specific CLCS Major Subsystem (RTPS, SDC, BIN, SIM) is named, the requirement is allocated only to CIs in that specific Subsystem.

# 2. CLCS SYSTEMS REQUIREMENTS

This section contains the systems requirements for the CLCS. It is organized into five subsections. The first subsection contains the requirements that apply to more than one of the major CLCS subsystems. The remaining four subsections contain the requirements specific to each of the major CLCS subsystems:

1. Real-Time Processing System Requirements
2. Business and Information Network Requirements
3. Shuttle Data Center Requirements
4. Simulation Requirements

## 2.1 CLCS SYSTEMS REQUIREMENTS

This section contains the CLCS Systems Requirements that are applicable to more than one of the major subsystems within the CLCS.

### 2.1.1 EXTERNAL SYSTEMS INTERFACE REQUIREMENTS

The CLCS must provide various external systems interfaces. Some of these interfaces, namely ones to the Flight Vehicle, are the same as those used by the CCMS. Refer to Table 2.1 for a summary of the external systems.

| EXTERNAL | INTERFACE | TYPE | DATA RATE | INTERFACE POINT |
|---|---|---|---|---|
| Interface | Launch Data Bus | Serial | 1 Mbs | Gateway Interface Adapter |
| Interface | Orbiter OFI PCM Downlink | PCM | 64 Kbs, 96 Kbs, 128 Kbs, 192 Kbs | Gateway Interface Adapter |
| Interface | Main Engine PCM Downlink | PCM | 60 Kbs | Gateway Interface Adapter |
| Interface | PCM Uplink | PCM | 32 Kbs, 72 Kbs, 128 Kbs | Gateway Interface Adapter |
| Interface | Ground Data Bus | Serial | 1 Mbs | Gateway Interface Adapter |
| Interface | Facility Timing UTC | IRIG | | Facility Timing System |
| Interface | Facility Timing CDT/MET | IRIG | | Facility Timing System |
| Interface | Biomedical | | | Gateway Interface Adapter |
| Interface | Hardwire Safing System | Discrete | | LCC Hardwire Safing Patch Panel |
| External Intelligent System | GMS | Ethernet UDP/IP | | Gateway Interface Adapter |
| External Intelligent System | Metro | Serial RS-422 | | Gateway Interface Adapter |
| External Intelligent System | HUMS | | | Gateway Interface Adapter |
| External Intelligent System | B/U HGDS | | | |
| External Intelligent System | EDAMS | | | |
| External Intelligent System | SCAN | Ethernet TCP/IP | | Network Gateway/Router |
| External Intelligent System | SDS | | | |
| External Intelligent System | SDC | | | |

| EXTERNAL | INTERFACE | TYPE | DATA RATE | INTERFACE POINT |
|---|---|---|---|---|
| External Intelligent System | SPDMS | Ethernet TCP/IP | | Network Gateway/Router |
| Network | KSDN | None | N/A | None |
| Network | LON | Ethernet TCP/IP | | Network Gateway/Router |
| Network | LSDN | Ethernet TCP/IP | | Network Gateway/Router |
| Network | Internet | Ethernet TCP/IP | | Network Gateway/Router |
| CLCS Set Location | LCC | Facility | N/A | Facility |
| CLCS Set Location | CCS | Facility | N/A | Facility |
| CLCS Set Location | HMF | Facility | N/A | Facility |
| CLCS Set Location | CITE | Facility | N/A | Facility |
| CLCS Set Location | SAIL | Facility | N/A | Facility |
| CLCS Set Location | KATS | Facility | N/A | Facility |
| Data Destination | Marshall Space Flight Center (MSFC) | | | |
| Data Destination | Johnson Space Center (JSC) | | | |
| Data Destination | Stennis Space Center | | | |
| Data Destination | Dryden Flight Research Center (DFRC) | | | |
| Data Destination | Payload Operations Control Centers (POCC) | | | |

**Table 2.1 - External Systems Interfaces**

#### 2.1.1.1 Launch Data Bus (LDB) Interface

The Launch Data Bus (LDB) supports the common software interface between the Orbiter data processing system and all applicable ground facilities for test, checkout, maintenance, preflight, and post-flight phases. In addition, this common software interface provides the RTPS with access to the devices that are attached to the LDB when the General Purpose Computers (GPC) are not active on the LDB.

The LDB is a burst-mode (40 MSec spacing) asynchronous bi-phase Manchester II encoded 1 Mbs data bus using 28 bit words. There are two identical, independent Launch Data Buses. The two LDBs may be used as a redundant pair, or may be used independently, as needed.

Although part of the LDB is a true bi-directional, half-duplex, redundant data bus, most of the ground portion of the bus consists of two sets of unidirectional data lines; two Uplink buses and two downlink buses. The LDBs are simplex data buses between the RTPS gateway and the Orbiter LPS Signal Adapter (OLSA), and full duplex serial buses between the OLSA and the Orbiter. At the interface to the RTPS Gateway, the electrical signal is a differential 1 VP-P +/- 0.2 VP-P at 124 Ohms balanced.

2.1.1.1.1 The RTPS shall meet the requirements allocated to the LPS/LDB interface specified in:

1. SS-P-0002-150, Space Shuttle LDB Software Interface Requirements
2. ICD-2-0A003, Section 3, Flight Vehicle/LPS Computational Systems Interface

2.1.1.1.2 The RTPS shall provide the capability, in GPC Mode, to issue commands and to receive measurement data, via the GPCs, from:

1. Orbiter Multiplexers/Demultiplexers (MDM) (i.e., Flight Critical, Payload, Flex, SCA, and Command Decoders)
2. Master Events Controller
3. Pulse Coded Modulation Master Units (PCMMU)
4. Mass Memory Units (MMU)
5. SSME Controllers
6. Solid Rocket Booster (SRB) MDMs
7. Engine Interface Units (EIU)
8. Payload Data Interleaver (PDI)
9. Payload Signal Processor (PSP)
10. Space Lab (SL) Experiment/Subsystem Computers

2.1.1.1.3 The RTPS shall provide the capability, in Direct Input/Output (DIO) Mode (i.e., when the GPCs are not active), to issue commands to and receive measurements from:

1. Solid Rocket Booster MDMs
2. Command Decoder MDMs

2.1.1.1.4 The RTPS shall provide the capability to interface with all GPC Functional Interfaces available via the LDB, including:

1. Systems Software Avionics Command Support (SACS)
2. Test Control Supervisor Single Commands (TCS-1)
3. Test Control Supervisor Test Sequences (TCS-S)
4. Mass Memory (MM)
5. Space Shuttle Main Engine (SSME) Load Program (SLP)
6. Launch Sequence (LS)

2.1.1.1.5 The RTPS shall provide the capability to load, modify, dump, and verify the Orbiter Computational Facilities (OCF) according to the following matrix:

| Function | GPC Main Memory | TCS Registers | Mass Memory | DEU Memory | SSME |
|---|---|---|---|---|---|
| Load | | X | X | X | X |
| Dump | X | X | X | X | X |
| Verify | X | | X | X | X |
| Modify | X | | X | X | X |

2.1.1.1.6 The RTPS shall provide the capability to synchronize Greenwich Mean Time (GMT) on board the Orbiter's Master Timing Unit (MTU) to Universal Time Coordinated (UTC) with an accuracy of less than or equal to 1 MSec.

#### 2.1.1.2 OFI PCM Downlink Interface

The Operational Flight Instrumentation (OFI) Pulse Code Modulation (PCM) downlink interface consists of a one-way telemetry data stream from the Orbiter PCM Master Unit (PCCMU). This downlink is the primary method for the Orbiter to communicate measurements, health, and status to the ground system.

The Orbiter OFI PCMMU transmits Operational Instrumentation (OI) data, GPC data, and Payload (PLD) data in a Bi-Phase-L time division multiplexed data stream at 64 Kbs, 96 Kbs, 128 Kbs, and 192 Kbs. The 96 Kbs and 192 Kbs data streams contain 32Kbs and 64 Kbs of voice data respectively. The voice data is not directly processed by RTPS. The downlink may consist of several variable length and content formats. The signal is a unidirectional continuous data stream using bi-phase Manchester II encoding. At the CLCS Gateway, the electrical signal is differential 1 VP-P +/- 0.2 VP-P at 124 Ohms balanced.

2.1.1.2.1 The RTPS shall provide the capability to receive, decommutate, and process PCM downlink information from the PCMMU as described in:

1. ICD-2-0A003, Flight Vehicle/LPS Computational Systems Interface
2. ICD-2-19001, Shuttle Orbiter/Cargo Standard Interfaces
3. SS-P-0002-140, Space Shuttle Downlist/Uplink Software Requirements

2.1.1.2.2 In addition, the RTPS shall provide the capability to receive, decommutate, and process payload PCM downlink information as described in:

1. ICD-2-0A003, Section 12, Flight Vehicle/LPS Computational Systems Interface

### 2.1.1.3 Main Engine PCM Downlink Interface

The Space Shuttle Main Engine (SSME) Pulse Code Modulation (PCM) downlink interface consists of three separate one-way telemetry data streams from the Orbiter Main Engine Controllers (MEC) via the Engine Interface Units (EIU). This downlink is the primary method for the SSMEs to communicate measurements, health, and status to the ground system.

The three Main Engine Controllers each transmit a 60 Kbs NRZ-L data stream via the launch umbilicals while the Flight Vehicle is on the pad, and all three data streams are multiplexed into the S-band Frequency Modulated (FM) signal during ascent. Unlike the multi-format OFI downlink, the SSME downlink consists of a single fixed format. The signal is a unidirectional continuos data stream using bi-phase Manchester II encoding. At the CLCS Gateway, the electrical signal is differential 1 VP-P +/- 0.2 VP-P at 124 Ohms balanced.

2.1.1.3.1 The RTPS shall provide the capability to receive and process PCM downlink information from the three Space Shuttle Main Engine Controllers as defined in:

1. ICD-2-0A003, Section 5, Flight Vehicle/LPS Computational Systems Interface.

### 2.1.1.4 PCM Uplink Interface

The Pulse Code Modulation (PCM) Uplink interface provides the capability to transmit commands to the Orbiter and payloads via the Orbiter General Purpose Computers (GPC).

The PCM Uplink is a time division multiplexed data stream that operates in one of two modes: the operational mode or the forward link mode. In the operational mode, the Uplink is transmitted at a rate of 32 Kbs or 72 Kbs from the ground to the Network Signal Processor (NSP) on-board the Orbiter. In the forward link mode data is transmitted at 128 Kbs to the Communications Interface Equipment (CIE) on-board the Orbiter via the Communications and Tracking (C&T) station.

The command Uplink consists of a 6.4 Kbs command channel, 1.2 Kbs of sync, and 0.4 Kbs of Station Identifier (ID). The remainder of the bandwidth is dedicated to voice. The RTPS does not supply the voice data, but instead provides an alternating 1-0 bit fill pattern. The signal is a unidirectional continuous data stream using bi-phase Manchester II encoding. At the CLCS Gateway, the electrical signal is differential 1 VP-P +/- 0.2 VP-P at 124 Ohms balanced.

2.1.1.4.1 The RTPS shall provide the capability to Uplink commands to the Orbiter GPC via the PCM Uplink interface as defined in:

1. SS-P-0002-140, Space Shuttle Downlist/Uplink Software Requirements.

[**Question**: Do we still need to provide the CITE Uplink capability (i.e., no NSP)? ]

### 2.1.1.5 Ground Data Bus Interface

The Ground Data Bus (GDB) communicates with Hardware Interface Modules (HIM) located at various locations around the LC-39 area to control and monitor Ground Support Equipment (GSE) and facilities. There are two types of HIMs, the original CCMS HIMs, plus the HIM-IIs designed by Core **[Ken—Should be referring to Core at all?]** and procured after Core's cancellation. The HIM-IIs implemented a 44-bit protocol in addition to the HIM 28-bit protocol to allow higher resolution analog input cards to be used.

The Ground Data Bus is a burst-mode (100 usec spacing), bi-directional, full-duplex, asynchronous 1 Mbs Manchester II data bus. The HIM uses a 28-bit packet (GSE Type-I), while the HIM-II utilizes a 44-bit packet structure (GSE Type-II). At the interface to the RTPS Gateway, the electrical signal is a differential 1 VP-P +/- 0.2 VP-P at 124 Ohms balanced.

2.1.1.5.1 The RTPS ground data bus shall communicate with both the CCMS Hardware Interface Module (HIM), and the replacement HIM-II.

2.1.1.5.2 The RTPS shall communicate using the GSE Type-I Data Bus (28-bit) with the HIM via the protocol described in:

1. CP90IT0916 Launch Processing System Checkout, Control and Monitor Subsystem Hardware Interface Module Assembly.

2.1.1.5.3 The RTPS shall communicate using the GSE Type-II Data Bus (44-bit) with the HIM-II via the protocol described in:

1. 83K001120 HIM-II Detailed Design Document

2.1.1.5.4 The CLCS shall support a minimum of two (2) GSE Data Buses per RTPS Gateway.

**Rationale:** The existing system supports two data buses per FEP, and the current cable plant and GSE redundancy (i.e., how end items are connected to HIMs) is based on this number.

2.1.1.5.5 The RTPS shall support a minimum of eight (8) HIM/HIM-IIs per data bus.

**Rationale:** The CCMS system supports eight HIMs per data bus, and the current cable plant and GSE redundancy (i.e., how end items are connected to HIMs) is based on this number.

2.1.1.5.6 The RTPS shall support any possible mixture of HIMs and HIM-IIs on the same data bus using the GSE Type-I Data Bus protocol. Only HIM-IIs shall be supported using the Type-II Data Bus.

**Rationale:** It is unlikely that HIM-IIs will be installed collectively, and therefore a mixture of HIMs and HIM-IIs may exist during the installation period.

2.1.1.5.7 The RTPS shall receive and process all HIM-II health and status commands as specified in:

1. 83K001120 HIM-II Detailed Design Document

2.1.1.5.8 The RTPS shall be capable of polling HIMs 19.9 miles from the RTPS gateway [Question: This was a big driver during Core. The current GSE FEP only supports 9.9 miles. Do we want to extended it? Should we specify distance to first HIM, distance between HIMs, etc.? ]

#### 2.1.1.6 Facility Timing UTC Interface

The CLCS needs reference to absolute Universal Coordinated Time (UTC).

The Coordinated Universal Time (UTC) interface receives UTC from the Timing Terminal Unit in IRIG-B123 format and processes the input data stream into time-of-day data words for distribution within CLCS.

2.1.1.6.1 The RTPS shall be capable of accepting and processing a continuous IRIG-B123 signal as defined in:

1. KSC-GP-792, Section 2.8, Timing Signal Formats
2. IRIG-200-96, sections applicable to IRIG-B123, Inter-Range Timing Formats

2.1.1.6.2 All RTPS subsystems shall maintain an absolute time reference within (TBD) microseconds of the UTC reference.

#### 2.1.1.7 Facility Timing CDT/MET Interface

Countdown Time (CDT) and Mission Elapsed Time (MET) are generated by the CLCS and used by various components of RTPS and external users as a reference for the current location within the countdown or mission. CDT becomes MET when time passes from minus time to positive time.

2.1.1.7.1 The RTPS shall be capable of outputting CDT/MET at a 1 millisecond rate to the facility timing interface in the MILA format described in:

1. (TBD)

2.1.1.7.2 The RTPS shall provide the capability to set, start, stop, hold, and resume CDT/MET.

[**Question**: Do we still need to provide the capability to start/stop the 'time remaining' clocks in the firing Rooms? This is accomplished by a set of discrete outputs (i.e., a HIM chassis and card) located in the CDBFR timing rack today. ]

#### 2.1.1.8 Biomedical Interface

The biomedical system monitors life support, environmental, and vehicle personnel medical and related data.. The biomedical data is transmitted via the Orbiter OFI PCM downlink. In addition to this data, vehicle safing measurement are found in this stream The biomedical interface, biomedical console, and safing interface have been upgraded in the last three (3) years. This interface need to be integrated into the CLCS design. This will require modification to support system health and load and interfacing to the new safing panel design.

2.1.1.8.1 The CLCS shall be capable of providing data to the Biomedical system as described in:

1. (TBD)

2.1.1.8.2 The Biomedical system shall be modified to accept software and parameter loads from the CLCS, and to provide health and status data to the CLCS (i.e., be integrated into the CLCS implementation).

#### 2.1.1.9 Hardwire Safing System / Safing Panels

The Hardwire Safing System provides an alternate means of controlling and monitoring critical GSE and Flight Vehicle systems in the event of a failure of the LPS and RTPS. On the GSE side, this consists of mostly hardwired 28v lines that perform two functions: cut-off the power to selected HIMs, thereby returning their outputs to a zero (de-energized) state; and provide direct control and monitor of selected GSE components. On the Flight Vehicle side, the safing system allows pre-coded safing sequences to be issued from the LDB FEP and preselected downlist measurements to be displayed without the use of the CDBFR or console subsystems.

2.1.1.9.1 The RTPS shall be capable of accepting discrete signals to trigger predefined Vehicle Safing sequences to be output up the Launch Data Bus.

2.1.1.9.2 The RTPS shall be capable of accepting discrete signals to toggle which LDB the Vehicle Safing sequences will be output on.

2.1.1.9.3 The RTPS shall be capable of accepting discrete signals to choose which LDB Gateway executes Vehicle Safing Sequences.

2.1.1.9.4 The RTPS shall be capable of outputting predefined discrete and analog measurements from the Orbiter OFI downlist to the Hardwire Safing System.

[**Question**: I have not specified requirements for the HIM power cut-off since CLCS is not replacing the HIMs or the Safing Panels themselves. Likewise, I have not specified requirements for GSE control for the same reasons. ]

#### 2.1.1.10 Ground Measurement System (GMS) Interface

2.1.1.10.1 The Ground Measurement System (GMS) interface shall be via an Ethernet network using UDP/IP.

2.1.1.10.2 GMS interface requirements are defined in:

1. (TBD)

#### 2.1.1.11 Pad Meteorological System (Metro) Interface

2.1.1.11.1 The Pad Meteorological System (Metro) shall provide weather data via a buffered RS-422 interface.

2.1.1.11.2 The Metro system interface requirements are defined in:

1. KSC-DL-3768, Metro Data Stream Definition

#### 2.1.1.12 Hydrogen Umbilical Mass Spectrometer (HUMS) Interface

The HUMS is a mass spectrometer equipped with a turbo-molecular vacuum pump to allow the analysis of gases primarily composed of helium. It provides back-up for the combustible gas sensor leak monitors and can be switched to monitor any sample line from the Prime and Back-up Hazardous Gas Detection System (HGDS).

#### 2.1.1.13 Backup HGDS Interface

#### 2.1.1.14 EDAMS Interface

#### 2.1.1.15 SCAN Interface

2.1.1.15.1 The Shuttle Connector Analysis Network (SCAN) interface shall be via an Ethernet network using TCP/IP.

#### 2.1.1.16 SDS Interface

#### 2.1.1.17 SDC Interface

#### 2.1.1.18 SPDMS Interface

The Shuttle Processing Data Management System (SPDMS) consists of an integrated set of application software, computer hardware, operating systems, database managers, and communications network hardware and software. SPDMS takes advantage of the increased computing power of the intelligent workstations while making data readily available.

2.1.1.18.1 The Shuttle Processing Data Management System, (SPDMS) interface shall be via an Ethernet network using TCP/IP.

#### 2.1.1.19 Kennedy Switched Data Network (KSDN)

The Kennedy Switched Data Network is being phased out of service, and CLCS should not need to interface to it.

#### 2.1.1.20 LON Network Interface

2.1.1.20.1 The Launch Operations Network (LON) interface shall be via an Ethernet network using TCP/IP.

#### 2.1.1.21 LSDN Network Interface

2.1.1.21.1 The LPS Software Development Network (LSDN) interface shall be via an Ethernet network using TCP/IP.

#### 2.1.1.22 Internet

This is the ‘real’ Internet, with appropriate firewalls and gateways to ensure we do not do anything dumb.

2.1.1.22.1 The Internet interface shall be via an Ethernet network using TCP/IP.

[**Question**: Does CLCS interface to the Internet, or do we use LON as out gateway? ]

#### 2.1.1.23 LCC Set Location

The Launch Control Center is located at KSC in the LC-39 area **[Ken—area reference?]** and is the primary monitor and control location for Shuttle **[Ken—Term?]** processing and launches. This building contains most of the RTPS and SDC equipment, and all SIM equipment.

#### 2.1.1.24 CCS Set Location

The existing Complex Control Set (CCS) is located in the LCC and is used to monitor and control facility systems in the KSC LC-39 area **(Ken—Area Reference?).**

[**Question**: What is happening with CCS? Are the RTUs going away and being replaced by HIM-IIs or similar? What functions are being moved to the OCR/MFRs?. ]

#### 2.1.1.25 HMF Set Location

The Hypergolic Maintenance Facility (HMF) is located in the KSC Industrial Area. It is used for off-line processing of the Orbital Maneuvering System (OMS) and Reaction Control System pods (RCS). The CLCS interfaces at HMF consist of GSE data buses, facilities (power, ground, etc.) and data networks back to LC-39. There are no PCM or LDB interfaces at HMF.

#### 2.1.1.26 CITE Set Location

The Cargo Integrated Test Equipment (CITE) system simulates the interfaces between the Orbiter and the experiments in its cargo bay. CITE consists of a combination of hardware and software. The combination of the two is integrated to perform cargo to Orbiter Interface Verification Testing (IVT) prior to the installation of the cargo into the Orbiter cargo bay. The CITE system provides functional simulation of Orbiter avionics and power interfaces to the payload elements in the prelaunch, ascent and on-orbit configurations. CITE is designed to do this by verifying electrical and mechanical compatibility with the Orbiter and provide recovery time to repair incompatibilities. As sometimes more than one payload is carried on a flight, payload to payload compatibility is also verified. CLCS interfaces at CITE consist of OFI PCM, LDB, facilities (power, ground, etc.) and data networks back to LC-39. There are no GSE interfaces at SAIL.

#### 2.1.1.27 SAIL Set Location

The Shuttle Avionics Integration Laboratory (SAIL) is located at JSC. SAIL is used to perform interface testing between the CLCS equipment and software, and an actual flight-rated set of Orbiter avionics. SAIL consists of a CLCS set (also named SAIL) and the ‘rig’ which is composed of a full set of Orbiter avionics and is used by Loral (ex-IBM) and Boeing (ex-Rockwell) **[Ken—company references?]** to perform validation testing of the Orbiter hardware and software. The CLCS interfaces at SAIL consist of OFI PCM, SSME PCM,PCM Uplink, LDB, facilities (power, ground, etc.) and data networks back to KSC. There are no GSE interfaces at SAIL.

#### 2.1.1.28 KATS Set Location

The Kennedy Avionics Test Set (KATS) is a limited set of Orbiter avionics located in the VAB at KSC.

[**Question**: Does CLCS really have any interfaces to KATS, or are KATS interfaces simply extended to one of the LCC sets? These should be LDB and OFI PCM. ]

#### 2.1.1.29 Marshall Space Flight Center Interface

The Marshall Space Flight Center (MFSC) includes a number of interface organizations including the (HOSC) Pratt & Whitney, Stennis and others. It is interfaced using COTS Ethernet hardware by way of 2,000 Kbs of allocated PSCNI **[Ken--?]** bandwidth using a point to point server. This interface permits interfacing to the Shuttle Data Stream (SDS) which allows selection of full rate date from any KSC operation. Backup is provide by PSCNI. Various other client are supported by point to point service from KSC over PSCNI. or redistribution from Marshall. In addition main engine raw data is sent to (MSFC).

#### 2.1.1.30 Johnson Space Center Interface

The Mission Operations Integration Room (MOIR)/Mission Evaluation Room (MER) provides facilities to monitor shuttle testing and launch operations. The Mission Evaluation Room (MER) at JSC provides facilities to monitor shuttle **(Ken—Term?)** testing and launch operations. It is interfaced using COTS Ethernet hardware by way of a 750 Kbs point to point LON gateway link. This interface permits interfacing to the Shuttle Data Stream which allows selection of full rate date from any KSC operation. Backup is provide by PSCNI. In addition, an RNET interface is provided to download KSC with mission files. This interface uses standard based communications over PSCNI.

2.1.1.30.1 CLCS shall provide an interface to the MER as described in:

1. (TBD)

#### 2.1.1.31 Stennis Space Center Interface

A two way connection by way of PSCNI exists to exchange real-time engine test data between the two centers **(Ken—KSC and Stennis? SSC?).** It is interfaced using COTS Ethernet hardware using PSCNI. This interface permits interfacing to the SDS which allows selection of full rate date from any KSC operation and select engine test stand data from Stennis to be exchanged. In addition, launch data may be sent to Stennis.

#### 2.1.1.32 Dryden Flight Research Center Interface

Dryden Flight Research Center (DFRC) receives data from KSC for support of landing operations. It is interfaced using COTS Ethernet hardware by way of a 750 Kbs point to point LON Gateway link. This interface permits interfacing to the SDS which allows selection of full rate date from any KSC operation. Backup is provide by two PSCN 19.2 baud dedicated circuits and 2400 baud dial up. Landing plus one day support is provided by a mini CLCS set.

#### 2.1.1.33 Payload Operations Control Centers Interface

Space Lab science missions are controlled from the Payload Operations Control Center (POCC) in Huntsville, Alabama. From this location, science operations can be directed, commands can be sent to the Orbiter, data can be received and analyzed from the on-board experiments and mission schedules may be adjusted.

#### 2.1.1.34 Local Acquisition and Control Systems Interface (from Rick Dawson)

#### 2.1.1.35 Vehicle Health Management System Interface (from Rick Dawson)

The Vehicle Health Management System (VHMS) provides an expert software system to assist in support monitoring while an Orbiter is powered up. A model-based reasoning system known as the Knowledge-Based Autonomous Test Engineer (KATE), provides the framework for the VHMS expert system. The VHMS/KATE environment is composed of four basic modules. The Data Acquisition Module decodes the PCGOAL data stream into KATE data packets. The Reasoner Module executes a simulation of the systems and compares simulation data with the real-time data. The Diagnoser Module analyzes any miscomparisons between the simulation and the Real-Time data to isolate the most probable cause of the error. The User Interface Module provides a graphical interface for the user to monitor system information.

## 2.2 REAL-TIME PROCESSING SYSTEM REQUIREMENTS

The RTPS is the portion of the CLCS that provides real-time process control for the Space Shuttle Flight Vehicle and supporting Ground Support Equipment during pre-launch processing, checkout, and launch. This system is similar to the Checkout, Control, and Monitor System (CCMS) in the LPS. The RTPS is essentially a command and control system that provides manual and automated processes for controlling end item hardware and software found in environments such as the processing facilities at the Kennedy Space Center (KSC). Although the RTPS is similar in many regards to the CCMS it differs in a number of significant ways:

1. The RTPS utilizes COTS technology and open architecture standards when task requirements can be met by this strategy. In the CCMS, proprietary technologies, restricted memories and the low processing power available in computers in the mid-70s forced a design that was tailor made to the processors in the system. This tailoring made it extremely difficult and costly to upgrade processors and the software residing in them. The COTS standards allow the capability to upgrade processors or software in a much more cost effective manner.
2. The RTPS is a message based system rather than a storage based system. In the CCMS, current values of measurements were stored in the Common Data Buffer (CDBFR). These values were updated only when the measurement value changed by a significant amount. Messages were sent to registered applications only when an exception violation occurred. In the RTPS, all measurement changes are distributed throughout the entire system.
3. The RTPS operates on higher levels of data than the CCMS. In the CCMS, only measurement and command data were available to all users. In the RTPS, higher levels of data are constructed and managed within the system in a manner similar to the way in which measurement and command data were handled in the CCMS.
4. RTPS mechanisms provide users and applications more details regarding the health of the measurement data available to them. For example, when a measurement link is down, the situation is reported to the users and applications whenever requests for the measurement data are received or whenever the data health changes rather than requiring each application to analyze the system and determine if the data is valid.
5. The newer hardware technologies of today, incorporated within the RTPS, bring inherently greater Mean Time Between Failure (MTBF) times and lower Mean Time to Repair (MTTR) times, thus lowering maintenance costs and increasing system availability.

6. Due to the significant advances in graphics technologies, the RTPS has cost effective displays which are richer in content and meaning and easier to understand and use.

The RTPS must provide similar capabilities and functionality of the CCMS.

## 2.2.1 CRITICAL FUNCTIONS REQUIREMENTS

This section contains the RTPS Critical Function Requirements. These requirements serve as the drivers for the design of the RTPS.

### 2.2.1.1 System

2.2.1.1.1 The RTPS shall be fault tolerant. Specifically, the system shall provide the capability to recover from subsystem failures in the following areas:

1. Human Computer interface — providing test personnel visibility and manual control
2. Command and Control Processing of end item control applications
3. Data Distribution Processing — giving controlling applications and users visibility to the state of end item hardware
4. Critical data acquisition gateways (i.e., LDB, 128 & 192 Kb PCM, GSE)
5. Real Time Critical Network and the Display and Control Network

**Rationale**: The RTPS must provide safe processing and control capability for the Flight Vehicle and related GSE. Consideration should also be given to cost and expandability. Redundancy will be provided as necessary, the level of which will correlate with the criticality and practicality of the situation. For example, the Console Position equipment is not required to be redundant because launch control engineering personnel can move to a spare Console Position and continue working in the event of a Console Position equipment failure. Beyond the Console Position equipment, higher levels of redundancy and fault tolerance are needed than provided by LPS in order to ensure safety and reduce processing time and cost.

2.2.1.1.2 The CLCS shall be designed to have a high level of data integrity. Specifically the system shall provide the following:

1. No loss of command data within the CLCS
2. No loss of measurement data within the CLCS
3. No loss of measurement samples to applications requesting such service
4. No data which has been corrupted within the CLCS
5. Health data on a measurement basis

**Rationale**: The RTPS is a process control system for the Flight Vehicle and related GSE. It must provide safe, redundant, and reliable control for elements of ground and flight systems. Most of the decisions made by the users and applications are based on the data acquired by the system. In order for the decisions to be accurate they must be based on valid data. Although the RTPS cannot regulate the accuracy of data prior to its arrival in the RTPS, the CLCS must neither lose nor corrupt data once it has entered the system. Additionally, the users and applications must be notified whenever data acquired by the system is known to be stale (e.g., not currently being acquired because it isn't in the current telemetry format).

2.2.1.1.3 The loss of any RTPS Real Time Network component shall not cause switchover of more than one standby subsystem.

2.2.1.1.4 All RTPS subsystem computers shall be equipped with error detection and correction logic.

## 2.2.2 PERFORMANCE REQUIREMENTS

The Real-Time Processing System (RTPS) portion of the Checkout and Launch Control System (CLCS) must provide timely responses to both End-Item events and Human inputs to provide safe processing of launch vehicles. This section captures the critical performance requirements which affect multiple hardware and software components of the RTPS.

#### 2.2.2.1 System

2.2.2.1.1 The “system maximum data bandwidth” shall support 25,000 end item changes per second continuously.

2.2.2.1.2 The system shall support 50,000 end item measurement changes in a given second without losing any data.

**Rationale:** The system will need to have a flow control mechanism to support buffering instead of losing data when peak change rates occur. This system is being used to consolidate several systems. Some of these systems and their rates are TBD. Therefore the above requirements are written with expansion in mind. We do not want to say the system will support all changes on all links.

2.2.2.1.3 The system shall support 1,000 end item measurement changes during a 10 millisecond period.

2.2.2.1.4 The system shall provide the capability to issue a commands a single test (control) application to support every LDB command opportunity (120 milliseconds).

**Rationale:** The CLCS needs to provide the capability for an application to issue LDB commands without waiting on the response so that every available command opportunity can be used.

2.2.2.1.5 The system shall execute a GSE reactive sequence, which simply tests 10 FDs, changes the constraints on 10 FDs and responds to the notification with a command, in less than 100 milliseconds from the time the measurement (1000 samples per second) changes at the HIM input until the command is issued at the HIM output while the system is at the “system maximum data bandwidth” and the subsystem executing the sequence has 20 test applications executing.

2.2.2.1.6 The system shall execute a GSE control loop, which simply responds to the notification with a command, in less than 100 milliseconds from the time the measurement (1000 samples per second) changes at the HIM input until the command is issued at the HIM output while the system has a minimal data load and the subsystem executing the control loop has no other applications executing.

2.2.2.1.7 A command to change the constraints for up to 500 measurements shall take less than 250 milliseconds.

2.2.2.1.8 GSE command/response latency of a priority command, or of a non-priority command in an unloaded system, shall be less than 20 milliseconds from the time a test/control application issues the command until the response is received by the application.

2.2.2.1.9 GSE command/response latency of a non-priority command in a loaded system with 20 applications executing in the same subsystem shall be less than 100 milliseconds from the time the test/control application issues the command until the response is received by the application.

**Rationale:** The command/response latency includes the time from the application executing the command all the way out to the HIM and back to that application. This requirement is trying to capture the fact that the response to a command must be received before executing the next ‘instruction’ and that this is critical to the timely execution of test/control applications.

2.2.2.1.10 One user’s test applications shall be able to read 10,000 measurements, and “verify” them in a single second in an unloaded system.

2.2.2.1.11 The time from a measurement change being detected by the system until that measurement is available for retrieval shall be less than five seconds.

2.2.2.1.12 A near-real-time single measurement retrieval request shall begin to return data to the requester in less than five seconds.

2.2.2.1.13 The system shall support executing a manual command in less than one second from human execution to HIM output.

2.2.2.1.14 The Data Health Function shall support the "system maximum data bandwidth".

2.2.2.1.15 The Data Fusion function shall support the "system maximum data bandwidth" with one fusion calculation per change.

2.2.2.1.16 The Constraint Function's data limit function shall support three constraint checks per measurement FD while supporting the "system maximum data bandwidth", including Fusion FDs.

2.2.2.1.17 The Constraint Manager notification function shall be capable of providing 100 notifications per second while supporting the "system maximum data bandwidth".

2.2.2.1.18 The data distribution function shall support the "system maximum data bandwidth", plus 5,000 (20%) Data Fusion updates per second.

2.2.2.1.19 The system shall meet all GLS timing requirements specified in KLO-82-0071.

**2.2.2.2 Subsystem**

2.2.2.2.1 All gateways shall be able to support full link bandwidth with all values changing every sample.

2.2.2.2.2 RTPS shall be able to support full Uplink command rates on the following links:

- LDB - 8/second
- PCM Uplink - 16.67/second or 50/second
- GSE - 500/second.

2.2.2.2.3 All gateways shall be able to support table maintenance changes under a full data rate load.

2.2.2.2.4 All subsystems acquiring data from external GSE shall be synchronized to Range Time to within 10 microseconds to support 100 microsecond measurement time-stamping.

2.2.2.2.5 All subsystems (except workstations and GSE Link Gateways) shall be synchronized to Range Time within TBD microseconds to support 1 millisecond time-stamping of measurements.

2.2.2.2.6 The Display function shall, for a single workstation, support updating of 250 displayed FDs out of 500 in one second.

2.2.2.2.7 The Display function shall, for a single workstation, support updating 50% of the FD's on 13 windows with 100 FD's in each in one second (TBD, get P200SY words).

2.2.2.2.8 The Display function shall support, for a single workstation, up to 4000 FDs on screens that are active but not displayed.

2.2.2.2.9 The system shall, for a single workstation, display a new graphical screen with up to 500 FDs in one second when the screen (active but not displayed) is selected for viewing.

2.2.2.2.10 Screen capture (for screen printing, etc.) shall take less than 0.5 seconds from initiation until the user can control/change the display.

2.2.2.2.11 Screen print shall take less than ten seconds to a local dedicated printer.

2.2.2.2.12 Changing from one display to another shall take less than 250 milliseconds.

**2.2.2.3 Redundancy**

2.2.2.3.1 GSE and PCM Gateways, configured as a redundant pair, shall switch to the standby Gateway with no loss of measurement data and within 1 System Synchronous Rate Time Period of detection.

2.2.2.3.2 For Gateways (except LDB) configured as a redundant pair, switch-over for commands shall be completed in less than 20 milliseconds without any loss of commands.

2.2.2.3.3 LDB Gateway switch-over shall be accomplished without any loss of data or commands and shall be completed in less than 500 milliseconds.

#### 2.2.2.4 Non-Realtime

2.2.2.4.1 The wall clock time to complete a launch configuration Test Build shall not exceed 30 minutes.

2.2.2.4.2 The System Software (including COTS tools and Operating System) reload for a single subsystem shall take less than 30 minutes.

2.2.2.4.3 The time required to load a launch configuration Test Set shall not exceed 2 hours.

2.2.2.4.4 A loaded and initialized Launch Configuration Test Set shall take less than 5 minutes to be activated.

2.2.2.4.5 The time required to reconfigure a Test Set to a new Test shall not exceed 15 minutes, assuming the new Test was previously loaded..

2.2.2.4.6 The time required to reconfigure a failed Subsystem to an operational state, assuming all software is already loaded on local disk, shall not exceed 15 minutes.

## 2.2.3 MEASUREMENT AND COMMAND PROCESSING REQUIREMENTS

One of the aspects that makes the CLCS RTPS unique is its ability to process a wide variety of measurement data in various ways along with an integrated command and control capability. Many of the functions for processing measurement and command data are provided to improve the efficiency of developing application software (i.e., reduce the number of lines of code that must be written by application software developers). This section provides requirements relating to measurement and command processing in the RTPS.

#### 2.2.3.1 Acquisition and Distribution of Data

Data is acquired in the RTPS by Gateways attached to a variety of external systems.

2.2.3.1.1 The RTPS shall provide the capability to acquire data from the sources identified in the External Systems Interface Requirements Section 2.1.1 of this document.

2.2.3.1.2 The RTPS shall check each measurement acquired for change and if a change is detected shall convert the data to the RTPS internal format and distribute the data to users.

2.2.3.1.3 The RTPS shall maintain the current value of all Measurement FD for access by application SW.

2.2.3.1.4 The RTPS shall provide the capability for applications to request all changes of Measurement FDs and have them provided along with time of change and health at the time of change.

2.2.3.1.5 The RTPS shall provide changed measurement data to system and user applications at the System Synchronous Rate.

2.2.3.1.6 The RTPS shall provide changed measurement data to display applications at the Display Synchronous Rate.

2.2.3.1.7 The RTPS shall provide the capability to update measurement and command data when needed.

#### 2.2.3.2 Data Types and Formats

The CLCS must process all data types that exist on the GSE, Orbiter, and Payloads and that are processed by CCMS. In addition, the CLCS must process some data types which are not processed by CCMS, but which are required by the CLCS itself or systems that the CLCS will interface with in the future. Formats of measurement data in CLCS are important because of the ramifications various formats options have on:

1. Bandwidth of networks.
2. Processor computing power requirements.
3. Labor required to develop software in the various options.
4. Labor required to sustain data in the various options.

2.2.3.2.1 The CLCS shall process all data types processed by the CCMS except MODCOMP Floating Point Data Types. (See Appendix B)

2.2.3.2.2 The CLCS shall process the following additional data types.

| Measurement Types | Command Types |
|---|---|
| 12 bit GSE Analogs | 12 bit GSE Analogs |
| 16 bit GSE Analogs | 16 bit GSE Analogs |
| Multi-word digital patterns | Multi-word digital patterns |
| Strings | Strings |
| IEEE 754 floating point | IEEE 754 floating point |
| State (Enumerated) | State (Enumerated) |

**Rationale:** Some of the data types in the table above may be processed on some of the CCMS links. The CLCS requirement is to expand the links that can support these data types on the needed CLCS links.

2.2.3.2.3 The CLCS shall provide the capability to use calibrated engineering units in all system and application programs where program decisions are made or where the data is displayed, printed, or stored.

2.2.3.2.4 The CLCS shall provide the capability to use converted count data in all system and application programs where program decisions are made, or where the data is displayed, printed, or stored.

2.2.3.2.5 The CLCS shall provide the capability to update calibration values for measurements in the RTPS without loading new test control information or interrupting non affected applications.

#### 2.2.3.3 Command Processing

The CLCS must provide the capability to issue commands available with the LPS. In addition, the CLCS must issue new command types which will be required by systems that the CLCS will interface with in the future.

2.2.3.3.1 The CLCS shall provide the capability to issue all keyboard commands in Appendix C with a Y in the column titled “implement”.

2.2.3.3.2 The CLCS shall provide the capability to protect from inadvertent issuance of commands.

1. Prerequisite logic
2. Two step protocol required on critical commands entered from the keyboard (e.g., arm, execute, and disarm logic)

2.2.3.3.3 The CLCS shall provide the capability to restrict issuance of commands to only authorized users and applications.

#### 2.2.3.4 Display

The CLCS must provide the capability to monitor measurements and display them in a variety of ways to the Shuttle Systems Engineer.

2.2.3.4.1 The CLCS shall provide the capability to monitor all measurement data available to the test set.

2.2.3.4.2 The CLCS shall provide the capability to display the current value of a measurement and all data related to the measurement.

2.2.3.4.3 The CLCS shall provide the capability to plot data from both real time acquisition of the data and data retrieved from the recording media.

#### 2.2.3.5 Data Fusion, Data Health, and Constraint Management

Data fusion is the process of combining measurement data and RTPS system parameters into new, derived, data that may be used in the same manner as measurement data. For example a Fused FD could be created called APU Ready For Start. When a small set of measurements contain the proper values, the APU Ready For Start Fused FD would be true, otherwise it would be false. This Fused FD could be viewed or used in the same manner as any Measurement or System Function Designator (FD). The process for combining data may include algebraic and logical manipulation of data and conditional testing of system parameters or intermediate calculated values. The Fused data is a CLCS Measurement FD.

The data fusion capability is provided to reduce the cost of developing application software. Experience with the CCMS LPS has shown that thousands of lines of GOAL code are used in an effort to create data which is essentially measurement data at a higher level than the data that enters the system (e.g., APU Ready for Start, Ready for Launch). The code is repeated in many different programs for some of the values, and the data may not be up to date with the current state of the variables that create it.

2.2.3.5.1 CLCS shall provide the capability to define, view, and execute the algorithms for performing data fusion.

2.2.3.5.2 A Fused Data Function Designator shall be recalculated whenever any of its input parameters change.

2.2.3.5.3 When the value of a Fused FD changes the new value shall be transmitted to all users, and system or user applications along at the System and Display Synchronous Rates.

2.2.3.5.4 All Fused Data Function Designator changes and parameter changes to the Fused FD algorithms shall be recorded.

2.2.3.5.5 The Data Fusion function shall allow activation and deactivation of Fused Data Function Designator Processing.

2.2.3.5.6 The Data Fusion function shall provide the capability to set the value of a Fused FD.

The RTPS provides the capability to monitor Measurement FDs for a predetermined condition and notify personnel operating the Test Set and software applications executing within the Test Set that the monitored data no longer meets the predetermined condition. This capability is called Constraint Management. Constraint Management is similar to Exception Monitoring in the CCMS; however, it differs in the following manner:

| Function or Capability | Exception Monitor (CCMS) | Constraint Manager (RTPS) |
|---|---|---|
| Monitoring Accomplished On | End Item Measurement Data Only | All Measurement FDs |
| Monitoring Accomplished In | FEPs | DDP |
| Application Notification | 1 Set of GOAL Limits | Multiple Applications may set different constraints |
| Reactive Sequence and Display Notification | Control Logic/EMON Limits Combined | Multiple Limits for Constraint Viewer(s) & Reactive Sequence Applications |
| Display Capabilities | Dedicated EMON Page | Constraint Viewer(s) |
| Default Display Limits | N/A | Provided |
| Summary Constraint Management State | N/A | Provided |

2.2.3.5.7 CLCS shall provide the capability to monitor Measurement FDs at the rate the data changes and notify all system and user applications registered for the service when predefined limits are exceeded or constraint conditions are met.

2.2.3.5.8 CLCS shall provide the capability for multiple (TBD number) users and system or user applications to request notification of constraint events for each Measurement FD.

2.2.3.5.9 CLCS shall provide the capability for each user, and system or user application requesting constraint violation notification to specify the limits/condition under which they will be notified.

2.2.3.5.10 The CLCS shall provide the capability to monitor measurement data (both converted count data or calibrated engineering units) for out of limits excursions and notify registered users when any of the following conditions occur:

1. N samples in a row that meet the constraint
2. N samples in a given time that meet the constraint
3. There is less than a specified time between constraint events

2.2.3.5.11 CLCS shall provide the capability for any user and system or user application to create new constraints from an application, keyboard, or predefined file, determine and/or view the current constraints and their algorithms, or modify the list of constraints and select the algorithms relating to them.

2.2.3.5.12 All messages sent to and received from the Constraint Manager shall be recorded.

The CLCS provides the capability to inform user and systems or user applications when measurement data is not valid for a variety of reasons. For example, because of bandwidth limitations many measurements that are sent to the ground via PCM are not active during any given mission phase. It is important for users and system or user applications who must make decisions based on the value of a measurement to know that the utilized value is current and, to everyone's knowledge, valid. The system software will determine when measurements are not being updated and will pass this information along to users and system or user applications using the measurement data. Health information on a measurement contains the following.

1. Gateway Processing Status Information — OK/Fail
2. Data Path validity — OK/Warning
3. User advisory application — OK/Warning
4. Manual user inputs — OK/Fail

2.2.3.5.13 The RTPS shall automatically provide health data on all measurement and derived measurement data in the system.

2.2.3.5.14 Data health information shall be updated any time the health changes.

2.2.3.5.15 The RTPS shall provide health information to all users and system or user applications of measurement information.

2.2.3.5.16 Users and system and user application shall have the capability to view health and status information on individual and groups of measurements

2.2.3.5.17 The RTPS shall provide the capability to set and reset health and status

**Rationale:** There is a large amount of data in the CCMS that is not always available (e.g., each different PCM format contains a subset of the total downlist data, LRUs not installed, failed instrumentation). In addition, there is a substantial amount of code in GOAL applications that attempts to determine if a particular piece of data is valid at the time it is being used. The RTPS should automatically provide data health and status information to users and applications to ensure that erroneous decisions based on bad or stale data are not made. Updates to data health may be provided by future applications.

## 2.2.4 SYSTEM APPLICATIONS REQUIREMENTS

This section contains requirements relating to system services and applications programs. These programs are developed to collect in one place functions which are needed by many system and user applications programs.

### 2.2.4.1 Applications Services

2.2.4.1.1 The CLCS shall [Placeholder]

#### 2.2.4.2 System Services

**2.2.4.2.1** The CLCS shall **[Placeholder]**

#### 2.2.4.3 System Viewers

CLCS will provide a set of System displays which provide information to the user without the user creating a display application. These system viewers will provide information about Measurement FD's. There are other displays provided with CLCS which are discussed in the sections with the associated functionality.

2.2.4.3.1 The RTPS shall provide a set of System Viewers which provide selected data for display without requiring the user to develop a specific display.

2.2.4.3.2 The RTPS shall provide a FD Viewer which provides a mechanism for viewing all available information about a measurement FD.

2.2.4.3.3 The FD Viewer shall be linkable to user and system displays.

2.2.4.3.4 The FD Viewer shall provide a mechanism for viewing all available information about a measurement FD's Health.

2.2.4.3.5 The FD Viewer shall provide a mechanism for viewing all available information about a Fused FD.

2.2.4.3.6 The FD Viewer shall provide a mechanism for viewing information about constraints asserted against a specific measurement FD.

2.2.4.3.7 The FD Viewer shall update the information displayed only when selected by the user.

2.2.4.3.8 The RTPS shall provide a Constraint Monitor Viewer which provides a mechanism for asserting and viewing constraints against measurement FDs for Constraint Monitor purposes only.

2.2.4.3.9 The RTPS shall provide a Display Monitor Viewer which provides a mechanism for asserting and viewing information for selected measurement FDs for Display Monitor purposes only.

2.2.4.3.10 The Display Monitor Viewer shall periodically update the displayed Measurement FD information.

2.2.4.3.11 The RTPS shall provide the capability for user test applications to setup the Constraint Monitor and Display Monitor Viewers' FDs.

#### 2.2.4.4 Manual Command, Monitoring and Control

The CLCS provides a means of manually commanding, monitoring, and controlling end item hardware and software similar to the Command Processor in the CCMS. The Command Processor functions will be analyzed on a one for one basis and each function will be allocated to the appropriate area within the CLCS for development.

2.2.4.4.1 The CLCS shall provide, using a Graphical User Interface (GUI) paradigm, the capabilities identified in Appendix C with a Y in the column titled Implement.

#### 2.2.4.5 System Messages

The CLCS provides a central repository for messages which are utilized by custom system and application software developed for the RTPS. The repository contains information for each of these messages, known as System Messages, such as message text, source, severity etc. Using a System Message Viewer, users may register for and receive System Messages for a requested Message Group and Severity.

2.2.4.5.1 The CLCS shall provide a central repository for System Messages and their associated definitions.

2.2.4.5.2 The RTPS shall allow users to register for and receive recent and new System Messages for a requested Message Group and Severity.

2.2.4.5.3 Every System Message shall provide sufficient information regarding why the System Message is being generated.

2.2.4.5.4 The RTPS shall provide the capability to associate additional data with any System Message (e.g., Help and status information of a set of resources).

2.2.4.5.5 Each System Message shall have a unique identifier.

2.2.4.5.6 The RTPS shall record the occurrence of all System Messages.

2.2.4.5.7 The System Message Viewer shall provide an audible warning capability.

## 2.2.5 USER APPLICATIONS REQUIREMENTS

### 2.2.5.1 Prerequisite Logic

The CLCS provides the capability to verify that a set of conditions are met prior to executing end item commands. This capability is known as prerequisites or prerequisite sequence. A prerequisite sequence may be defined for all end item commands. When the prerequisite sequence is executed it verifies that a predefined set of conditions is met and if they are the command is executed. If not the command is rejected.

2.2.5.1.1 The CLCS shall provide the capability for a prerequisite sequence to be defined for every end item command.

2.2.5.1.2 The CLCS shall execute any prerequisite sequence defined for a command prior to executing the command.

2.2.5.1.3 The CLCS shall reject any command for which the predefined conditions are not met.

2.2.5.1.4 The CLCS shall allow rejected commands from the Command Processor to be overridden.

### 2.2.5.2 End Item Manager

2.2.5.2.1 The CLCS shall **[Placeholder]**

### 2.2.5.3 Test Applications Script

2.2.5.3.1 The CLCS shall **[Placeholder]**

## 2.2.6 SAFING AND BIOMED REQUIREMENTS

The CLCS must provide a totally separate system that provides the capability to bypass the CLCS RTPS. This system is referred to as the CLCS Safing System and consists of two major areas: Vehicle and Hardwired Safing. Both areas have Safing Panels for their HCI. Hardwired Safing is connected directly to sensors and effectors at the test site (e.g., PAD, VAB, etc.). Vehicle Safing is connected to the LDB Gateway where Vehicle Safing Sequences are loaded and executed. Vehicle Safing is connected to the PCM 128K Downlink prior to the PCM Gateway in order to acquire measurement data to be displayed on the panels.

The CLCS must also provide a BIOMED capability for the display of astronaut biomedical data on the BIOMED console. The BIOMED data must be acquired from the 128K PCM Downlink prior to the PCM Gateway. The existing CCMS Vehicle Safing and BIOMED (VSB) Gateway will be utilized as the mechanism to acquire the PCM data for both Vehicle Safing and BIOMED. The BIOMED console will be incorporated into a RTPS workstation (TBD).

### 2.2.6.1 CLCS Safing

2.2.6.1.1 The CLCS Safing System shall provide a totally independent Safing capability for the emergency control and monitoring of critical and/or hazardous systems.

2.2.6.1.2 A separate Safing System shall be provided for every End-Item Site supported by the LCC Set (VAB1, VAB2, OPF1, OPF2, OPF3, PADA, PADB).

2.2.6.1.3 The CLCS Safing System shall provide the capability to place the Test Article and support equipment in a safe state.

2.2.6.1.4 The Safing System Shall support the generic console concept by providing an easily re-configurable Safing panel.

2.2.6.1.5 A Safing panel shall be provided at every command and control console position in the LCC Set.

### 2.2.6.2 Vehicle Safing

2.2.6.2.1 The CLCS Safing System shall provide the capability to execute Vehicle Safing Sequences that are initiated by the user on a Safing Panel at the User Console Position.

2.2.6.2.2 The CLCS Safing System shall provide a master enable function that enables one (or none) of the LDB Gateways to execute Vehicle Safing Sequences.

2.2.6.2.3 The CLCS Safing System shall support executing a Vehicle Safing Sequence in less than 100 milliseconds from user initiation to the start of the Safing Sequence execution.

2.2.6.2.4 The Active, Standby and Hot Spare LDB Gateways shall be capable of supporting Vehicle Safing.

2.2.6.2.5 The CLCS Safing System shall support a minimum of 32 predefined independent Vehicle Safing Sequences.

2.2.6.2.6 The CLCS Safing System shall provide the capability to Display PCM Downlink Safing data on Safing panels.

2.2.6.2.7 The CLCS Safing System shall provide the capability to enable/inhibit individual Vehicle Safing Sequences.

2.2.6.2.8 The CLCS Safing System shall provide the capability to load Vehicle Safing Sequences into an active Gateway without disrupting operation of that Gateway.

2.2.6.2.9 All activities in progress prior to a power failure, except for Vehicle Safing, shall be purged from the LDB Gateway when power is restored.

2.2.6.2.10 The LDB Gateway shall support Vehicle Safing within 8 seconds after power restoration.

### 2.2.6.3 Hardwire Safing

2.2.6.3.1 Hardwired Safing shall provide direct effector control from the Safing System, bypassing the RTPS system.

2.2.6.3.2 Hardwired Safing feedback data shall be accomplished by sensors returning hard-wired voltages directly to the Safing System, bypassing the RTPS system.

### 2.2.6.4 BIOMED

2.2.6.4.1 The RTPS shall provide the capability to Display 128K PCM Downlink BIOMED data at the BIOMED console position(s).

2.2.6.4.2 The RTPS shall not record the BIOMED data.

## 2.2.7 SYSTEM ENVIRONMENT REQUIREMENTS

The RTPS is used in two distinctly different environments; the Operational Environment and the Development Environment. Each of the different environments consists of different sets of hardware and satisfies different objectives. This section details the environments and their requirements.

### 2.2.7.1 Operational Environment

The Operational Environment is itself composed of three distinct sets of hardware each of which is used in different ways.

1. Control Room Environments (i.e., LCC & Specialized Processing Sites)
2. Local Control Environment
3. Development Environments

#### 2.2.7.1.1 Launch Control Center Control Room Environments

The Control Room environment is one in which users use RTPS Workstations in rooms dedicated to the control and test of end items attached to the resources of the Test Set. These control rooms, known as, RTPS Sets, are used to control a wide variety of end items (e.g., Orbiters, Payloads, facilities equipment).

2.2.7.1.1.1 The CLCS shall provide a control room environment in which checkout and launch operations can take place in a controlled area.

2.2.7.1.1.2 The LCC Set shall be configurable into 8 separate Test Sets each of which can simultaneously perform different activities.

2.2.7.1.1.3 The LCC Set shall provide the capability to physically isolate critical Test Sets from other Test Sets.

2.2.7.1.1.4 The control room environment shall support the following operations:

1. Control of GSE and Orbiter in any OPF bay.
2. Control of GSE and Flight Vehicle in any Vertical Assembly Building (VAB) High Bay.
3. Control of GSE and Flight Vehicle at any KSC Launch Complex 39 Launch Pad.

#### 2.2.7.1.2 Specialized Processing Sites

The flexibility and versatility of the RTPS makes it suitable for process control of many facilities and end items other than the Space Shuttle. The RTPS control room environment is used in many areas other than the Launch Control Center both at KSC and other government facilities. These areas are called Specialized Processing Sites.

Typically a Specialized Processing Site contains much of the same hardware and software as the LCC Set. The main differences are quantities of equipment, and reduced redundancy. There are potentially additional requirements for the Specialized Processing Sites. These requirements are captured within the SLS in appropriate places (e.g., Fuel Cell Simulation for CITE)

2.2.7.1.2.1 The CLCS shall provide a control room environment in which process control operations can take place in a controlled area for Specialized Processing Sites.

2.2.7.1.2.2 The CLCS shall provide the following Specialized Processing Sites:

1. Hypergolic Maintenance Facility (HMF)
2. Cargo Integrated Test Equipment (CITE)
3. Shuttle Avionics Integration Lab (SAIL)

#### 2.2.7.1.3 Local Control

The local control environment is one in which RTPS Human Computer Interface equipment is being used in the vicinity of the end item(s) under test. This proximity of a user interface to the end item allows for a consolidation of engineering resources. Support personnel may conduct non-hazardous operations at the location of the end item under test rather than requiring engineering resources both in the OCR and in the vicinity of the test article.

Local Operations will provide the capability to introduce specialized test unique equipment into the CLCS environment. This equipment may be required at various times during processing flow.

**Local Subsystem Capabilities**

2.2.7.1.3.1 RTPS shall provide the capability to acquire data from test equipment; monitor RTPS measurement data; and control test equipment and RTPS End Items in close proximity to the End Item (locally).

2.2.7.1.3.2 RTPS shall provide an easily portable subsystem (hand-carried by one person) for local acquisition and control operations.

2.2.7.1.3.3 RTPS shall provide the capability for the local acquisition and control subsystem to operate in a standalone mode or as an integrated part of an RTPS Test Set (monitoring, commanding, recording, etc.).

2.2.7.1.3.4 RTPS shall provide the capability to time tag locally acquired measurement data and local commands.

**Recording**

2.2.7.1.3.5 RTPS shall provide the capability to record local commands and locally acquired measurement data on local media.

2.2.7.1.3.6 RTPS shall provide the capability for information recorded locally during standalone operations to be incorporated (post-test) with information recorded on the central RTPS recording subsystem.

**Access Control**

2.2.7.1.3.7 RTPS shall provide the capability for users in local environments to command/control any RTPS functions authorized for that user.

2.2.7.1.3.8 RTPS shall provide the capability to disable the command capability of non-local RTPS functions from a local workstation.

**Video**

2.2.7.1.3.9 RTPS shall provide the capability for local operations to use a video camera.

2.2.7.1.3.10 RTPS shall provide the capability to store video images for comparison purposes during local testing.

2.2.7.1.3.11 RTPS shall provide the capability to access stored video images at both local and control room workstations.

2.2.7.1.3.12 RTPS shall provide the capability for locally acquired video images to be displayed on both the local workstation and control room workstations.

### 2.2.7.2 Development Environments

The Development Environment is used primarily for software development, but integration of new hardware occurs in the development areas prior to being introduced into the operational environment. Systems integration and Test of hardware and software elements also occurs in the development environment. There are multiple areas where software development, integration, and test occur. Hardware and software adequate to perform the development is provided in each area.

#### 2.2.7.2.1 System and Application Software Development Environment

A number or sets of hardware and software are required for development, integration, and test of systems and application software.

2.2.7.2.1.1 The CLCS shall provide the following sets of hardware for development, integration, and test of software:

1. Satellite Development Environments
    a) 2 - System Software SDEs
    b) 1 - Application Software SDE
    c) 1 - System Software SDE at JSC
2. Integration Development Environments
    a) 1 - IDE without redundant hardware
    b) 1 - IDE with redundant hardware

2.2.7.2.1.2 The CLCS shall provide the capability to record and retrieve data to a local data store for debug purposes.

#### 2.2.7.2.2 Applications Debug Environment

The CLCS must provide a development environment in which Applications Developers can unit test their software without all of the equipment that will be required to run the program when it is placed in the operational environment. The capability must include rudimentary simulation; however, the fidelity of the simulation does not need to have the same performance characteristics or the same level of detail as the simulator providing full model support.

2.2.7.2.2.1 The CLCS shall provide an Application Debug Environment in which Systems and User Applications can be tested without the use of an OCR running against the simulator system.

## 2.2.8 SYSTEM CONTROL REQUIREMENTS

This section provides the requirements necessary to control the RTPS. Most of the requirements in this section provide the O&M User with the capability to control and manage the RTPS. It is organized similarly to the way the O&M Users control the system and contains subsections on:

1. Resource Management
2. Test Control and Progress Monitoring
3. System Integrity
4. Maintenance Functions

Much of the functionality in the System Control section is used to manage the resources in the LCC Set since this set is configurable into up to 8 smaller sets of hardware and software (Test Sets). These Test Sets may then be used to provide process control functionality of different facilities and end items.

### 2.2.8.1 Resource Management

Resource management is an activity that is typically accomplished in configurable sets (i.e., the LCC Set). It performs the initial allocation of resources and loading of software from the Set Master equipment in the Common Equipment Area (CEA). Once Test Sets are established within the LCC Set, control of the Test Set is accomplished from the Test Set Master Equipment in the Test Set area. In non-configurable sets many of the functions of Resource Management are not active since the hardware is not available to provide configurable Test Sets in these sets.

2.2.8.1.1 The RTPS shall provide the capability to manage all equipment in an RTPS set.

2.2.8.1.2 The CLCS shall provide the capability, in each configurable RTPS set, to control/configure all of the equipment in the set that may be allocated to multiple parallel Test Sets.

2.2.8.1.3 The CLCS shall provide the capability to define a Test Set Activity which contains a list of the HW (e.g., network resources, subsystems, end item connectivity, etc.), and SW resources (e.g., SCID, TCID, etc.) needed to perform the activity.

2.2.8.1.4 Test Set Activities shall be capable of being pre-defined, stored for later use, and modified during use.

2.2.8.1.5 The RTPS shall provide a set of visual displays that provide comprehensive insight into the state and configuration of the set resources (e.g., network resources, subsystem assignments, software configuration, etc.).

2.2.8.1.6 The RTPS shall provide different views of test sets and activities in configurable sets (e.g., Master Set View, Test Set View, Activity View).

**Setup and Allocation of Resources**

2.2.8.1.7 The RTPS shall provide physical and electronic devices to permit configuration of end item links to the RTPS gateways.

2.2.8.1.8 The RTPS shall provide the capability to configure subsystem hardware to support a defined Test Set Activity.

2.2.8.1.9 The RTPS shall provide the capability to assign network resources to processors within Gateway Groups, Control Groups, and Flow Zones (FZs).

2.2.8.1.10 The CLCS shall provide SW to assist in the configuration of the RTPS Test Set Hardware.

2.2.8.1.11 The RTPS shall provide a method to associate Gateway Groups with one or more Control Groups.

2.2.8.1.12 The RTPS shall provide a method to associate one or more Control Groups with a set of Workstation Positions to create a flow zone.

2.2.8.1.13 The RTPS shall provide the capability to configure users' workstations for selected activities

2.2.8.1.14 The RTPS shall provide the capability to monitor the current status of the assignment of network and processor resources.

**SW Load and Distribution**

2.2.8.1.15 The RTPS shall provide the capability to load and initialize the following Software in each subsystem of the Test Set:

1. Platform load
2. Subsystem Load (SCID)
3. Test SW Load (TCID)

2.2.8.1.16 The RTPS shall provide the O&M operator with the capability to select, load, monitor load progress, verify the load, and initialize all Software required in the Test Set.

2.2.8.1.17 The RTPS shall provide automated load capabilities for platform, subsystem, and test loads.

2.2.8.1.18 The RTPS shall provide the capability to verify the integrity of loaded software (i.e., presence, revision and CRC of required modules).

2.2.8.1.19 The RTPS shall provide the capability to verify the integrity of software loaded in a Test Set environment at any time.

### 2.2.8.2 Test Control and Progress Monitoring

Test Control and Progress Monitoring provides the O&M operator with the tools to control and monitor the status and health of a Test Set. Many of the tools provided by the requirements of Resource Management are also available in the Test Set area to augment capabilities provided by these requirements. For example the status displays provided by the requirements in Resource Management are available to perform Test Control and Progress Monitoring.

2.2.8.2.1 The RTPS shall provide Test Control and Monitoring for all subsystems in a Test Set.

2.2.8.2.2 The CLCS shall provide the capability to modify the hardware and software configuration of a Test Set during the execution of a test.

**Monitoring and Control of Hardware and Software**

2.2.8.2.3 The CLCS shall create a list of workstations, Subsystems, and network resources which will be allowed to participate in a named activity during the pre-configure activity.

2.2.8.2.4 The RTPS shall provide the capability to enable or disable commanding from any Gateway, CCP, or HCI.

2.2.8.2.5 The RTPS shall provide the capability to activate a test load.

2.2.8.2.6 The RTPS shall provide the capability to monitor each activity and determine what resources are participating in each activity.

2.2.8.2.7 The RTPS shall provide the capability to status and monitor the test configuration.

2.2.8.2.8 The RTPS shall provide a visual display depicting the health and status of all hardware resources within a Test Set and within all Test Sets of a Configurable Set.

2.2.8.2.9 The RTPS shall provide the capability to monitor the configuration of each subsystem participating in a test including what software is executing and any subsystem error conditions.

2.2.8.2.10 The RTPS shall provide a central point for the display of system error, status, and mode change messages.

2.2.8.2.11 The RTPS shall provide a central point for collection of LRU status and health.

**Fault Detection and Isolation**

2.2.8.2.12 The RTPS shall provide the capability to perform continuous fault detection and isolation of RTPS subsystem's hardware.

2.2.8.2.13 The RTPS shall provide a set of non-intrusive test programs to test interfaces and subsystem LRUs in the RTPS.

2.2.8.2.14 The RTPS shall provide the capability to scan all HIM outputs and confirm that they are the same as current commanded state.

**Note:** A capability called HIM Scan is provided to perform this requirement. It is used in a variety of situations:

1. To verify the status of commands on the HIMs are the same as those commanded by the RTPS.
2. It provides additional resources for recovery operations in the event of subsystem failures where automatic recovery doesn't occur.
3. It is also used in cases where HIMs have been powered up locally and commands have been issued.

**Resource Utilization**

2.2.8.2.15 The RTPS shall provide the capability to continuously monitor subsystem resource utilization in all RTPS subsystems.

2.2.8.2.16 The RTPS shall provide alarm messages when resource utilization levels exceed pre-defined limits.

2.2.8.2.17 The RTPS shall provide the capability to control the pre-defined limits of the subsystem resources that are being monitored.

2.2.8.2.18 The RTPS shall record resource utilization data for off-line analyses.

### 2.2.8.3 System Integrity

System Integrity and Redundancy Management are provided through several functions executing in the RTPS. These functions are available in all sets, however, redundancy does not work unless hardware and software resources are available and configured properly. System Integrity provides the main portion of redundancy management within the RTPS.

2.2.8.3.1 The RTPS shall provide redundancy management of all redundant subsystems and network resources in a Test Set.

**Redundancy Management**

2.2.8.3.2 The RTPS shall provide a central point to coordinate and direct redundant element activation (known as System Integrity).

2.2.8.3.3 System Integrity shall be capable of being run from any Console Position within a Test Set.

2.2.8.3.4 A redundant copy of System Integrity shall exist for use during critical control situations.

2.2.8.3.5 The RTPS shall provide a method to share current configuration data with a redundant element.

2.2.8.3.6 The RTPS shall provide a method to track redundant element states.

2.2.8.3.7 System Integrity shall monitor critical subsystems for failure and in the event a monitored subsystem fails, shall perform a switchover to the standby subsystem.

2.2.8.3.8 System Integrity shall report all subsystem errors to a central point.

2.2.8.3.9 The CLCS shall provide a reduced capability mode in which a Test Set continues to support even though all copies of System Integrity fail.

**Note:** Functions that are not supported or whose capability is reduced in the reduced capability mode are:

1. Redundant Element Switchover
2. Test Set Resource Monitoring
3. Checkpointing
4. Restarting subsystems

2.2.8.3.10 The CLCS shall provide a "warm boot" capability in which System Integrity can be restored after failure.

2.2.8.3.11 After a "warm boot" System Integrity shall restore normal function to those capabilities which were reduced while in the reduced capability mode.

**Rationale:** In the CCMS, the System Configuration Table (SCT) is maintained in the Master Console memory, Integration Console memory, and the CDBFR (copies are also maintained in each CPU). The SCT contains the current system configuration information (e.g., logical port to physical port addressing information, subsystem status). For a CCMS set to be fully operational, it must have an operating Master Console. If the Master Console fails, the Integration Console, where available, picks up the Master Console's functions. If the Integration Console also fails or isn't present when a Master Console fails, the system will continue to operate in a degraded mode. When the Master Console is brought back on line it is "Warm Booted" ; it reads the SCT from the CDBFR and uses the CDBFR SCT as the correct SCT. The CLCS needs to preserve many of these functions and capabilities (even though no CDBFR exists in the CLCS and the SCT may not exist).

2.2.8.3.12 After a "warm boot", the RTPS shall be restored to normal function.

2.2.8.3.13 After a "warm boot", the RTPS shall be capable of restoring to a checkpointed function.

**Checkpoint Restart**

2.2.8.3.14 The RTPS shall provide a method to store current configuration data,

2.2.8.3.15 The RTPS shall provide a method, in real-time, to make updates to stored configurations.

2.2.8.3.16 The RTPS shall provide a method to restore previously stored configuration data.

#### 2.2.8.4 Maintenance Functions

The Maintenance Function is dedicated for Organizational Level maintenance use. It provides O&M personnel with Operational Readiness Tests, and monitoring and diagnostic tools to maintain the HW and SW in the RTPS.

2.2.8.4.1 The RTPS shall provide a Maintenance Function for each subsystem in a Test Set.

**Maintenance Monitoring**

2.2.8.4.2 The Maintenance Function shall provide SW necessary to integrate and interpret operational and maintenance messages from the following areas:

1. System messages
2. Subsystem health and status information
3. RTCN and DCN network statistics and configurations
4. ORT results
5. Console port subsystem boot and error messages
6. Data from commercial network sniffers/analyzers

2.2.8.4.3 The Maintenance Function shall provide maintenance trend analysis and failure prediction capabilities.

2.2.8.4.4 The RTPS shall be able to run intrusive and non-intrusive diagnostics on any subsystem and on multiple subsystems concurrently.

2.2.8.4.5 The CLCS shall provide a recommended fault isolation tree.

**Interface Validation**

2.2.8.4.6 The RTPS shall be able to test subsystem LRU interfaces.

2.2.8.4.7 The RTPS shall be able to test each external interface.

**Operational Readiness Testing (ORT)**

2.2.8.4.8 The RTPS shall provide a set of Operational Readiness Tests (ORTs) that determine the readiness of any Test Set (System Level ORT) to support the activities defined for it.

2.2.8.4.9 The RTPS shall provide comprehensive ORTs that determine the readiness of any subsystem (Subsystem Level ORT) to support the activities defined for it.

**Diagnostics**

2.2.8.4.10 All LRUs and subsystems shall have a Power on Self Test (POST).

2.2.8.4.11 Diagnostics shall provide a visual indication of running and completion.

2.2.8.4.12 The RTPS shall provide a set of off-line programs to test the system hardware

## 2.2.9 RELIABILITY, MAINTAINABILTY, AND AVAILABILITY REQUIREMENTS

### 2.2.9.1 Reliability

2.2.9.1.1 **[Placeholder]**

### 2.2.9.2 Maintainability

## MTTR

2.2.9.2.1 All maintenance actions shall be able to be performed without removing rack or cabinet side panels.

2.2.9.2.2 LRUs shall be replaceable by one person without special tools.

2.2.9.2.3 Cable removal shall not require special tools.

2.2.9.2.4 Tests and adjustments shall be able to be made without LRU removal.

2.2.9.2.5 Minimal disassembly shall be required for preventive maintenance activities.

## Standards

2.2.9.2.6 Ribbon style connectors shall utilize locking devices.

2.2.9.2.7 Cables shall have adequate service loops and use part number and “mates with” labeling convention.

2.2.9.2.8 Parts shall be keyed for proper assembly.

## Identification

2.2.9.2.9 Fault indicators, fuses, and circuit breakers shall have plain English annotations.

2.2.9.2.10 LRU test point and scope ground connections shall be located on the accessible side of the LRU.

2.2.9.2.11 Ground connection test points shall not be adjacent to the Vcc plane.

2.2.9.2.12 LRUs shall have component designations and test point information silk screened on both sides of the printed circuit board.

2.2.9.2.13 LRU Ground and Vcc planes shall be clearly marked

2.2.9.2.14 Status of LEDs shall be visible without removing equipment covers or breaking seals.

2.2.9.2.15 Cables shall be routed so they are not pinched by doors, covers, etc. Sharp bends shall be avoided.

2.2.9.2.16 All plug and receptacles shall be labeled correctly.

2.2.9.2.17 LRUs shall utilize quick disconnects in lieu of soldered connections.

2.2.9.2.18 Power phasing requirements shall be clearly marked.

2.2.9.2.19 Cooling fans/filters shall be easily removed with minimal disturbance to the system.

2.2.9.2.20 A minimum of eight AC utility outlets shall be provided on all rack assemblies, four in the front and four in the rear.

2.2.9.2.21 All backplane signals shall have a means of attaching a scope probe (i.e., WW pin or test points).

2.2.9.2.22 If extender boards are required for servicing, adequate service loops for front card edge cabling shall be provided.

2.2.9.2.23 All Orbiter/GSE signal paths shall be capable of being monitored without opening racks or disrupting the signal path.

2.2.9.2.24 Equipment design shall facilitate rapid and positive fault detection and isolation of defective items to permit their prompt removal and replacement.

2.2.9.2.25 Equipment shall be capable of being assembled and disassembled in its operational environment by a minimum number of trained personnel wearing clothing appropriate to the operating environment specified for the system maintenance concept.

2.2.9.2.26 Removal of any replaceable item shall require opening or removing a minimum number of covers or panels.

2.2.9.2.27 Field removable items shall be replaceable by using only common hand tools.

2.2.9.2.28 Marking and color coding shall conform to MIL-STD-415.

2.2.9.2.29 Cables shall be routed so as to be accessible for inspection and maintenance.

2.2.9.2.30 Cable routing shall not obstruct visual or physical access to equipment for operation or maintenance.

2.2.9.2.31 Cables shall be long enough so that required checking of any functioning item can be accomplished in a convenient place. Extension cables shall be provided where this is not feasible.

#### 2.2.9.3 Availability

2.2.9.3.1 **[Placeholder]**

## 2.2.10 HUMAN FACTORS REQUIREMENTS

This section defines the human factors guidelines necessary to ensure that the design of the CLCS enhances productivity, comfort, and safety, and minimizes errors, fatigue, and stress. These requirements are not intended to preclude the use of COTS products. They are to be used as criteria for selection among COTS products, when available. When fully-compliant COTS products are not available, requirements cost/benefit analyses shall be performed of COTS vs. non-COTS solutions.

**2.2.10.1 Hardware Considerations**

2.2.10.1.1 The workstation and associated controls shall accommodate the physical and visual capabilities of the population based on anthropometry data for the range from the 5th percentile female to the 95th percentile male~~ as determined by the human factors engineer~~.

~~2.2.10.1.2 Equipment shall be designed to minimize the potential for human error.~~

2.2.10.1.2 Equipment shall be designed to preclude personnel hazards, injury, accidental shock to operators (minimized for maintenance personnel), and damage to clothing.

2.2.10.1.3 Display/control equipment and hardcopy-producing devices shall be designed so maintenance activities may be performed expediently and with minimal interference to workstation operators; safely; accurately; and with minimum requirements for personnel, skills, special tools, and cost.

2.2.10.1.4 Equipment and other peripheral devices shall be designed so maintenance activities may be performed expediently and with minimal interference to workstation operators; safely; accurately; and with minimum requirements for personnel, skills, special tools, and cost.

2.2.10.1.5 Whenever an operator must use a large number of controls and displays, their location and arrangement shall be designed to aid in determining which controls are used with which displays, which equipment component each control affects, and which equipment component each display describes.

2.2.10.1.6 For standing operations, work surfaces to support items such as job instruction manuals, worksheets, and logbooks shall be 35 +/- 0.6 inches above the standing surface, unless otherwise specified.

2.2.10.1.7 For seated operations, provisions shall be made for vertical seat adjustment from 15 to 21 inches in increments of no more than 1 inch each.

**~~2.2.10.2 Maintenance Requirements~~**

~~2.2.10.1.8 Equipment design shall facilitate rapid and positive fault detection and isolation of defective items to permit their prompt removal and replacement.~~

~~2.2.10.1.8 Equipment shall be capable of being assembled and disassembled in its operational environment by a minimum number of trained personnel wearing clothing appropriate to the operating environment specified for the system maintenance concept.~~

~~2.2.10.1.8 Removal of any replaceable item shall require opening or removing a minimum number of covers or panels.~~

~~2.2.10.1.8 Field removable items shall be replaceable by using only common hand tools.~~

~~2.2.10.1.8 Marking and color coding shall conform to MIL-STD-415.~~

**~~2.2.10.2 Failure Indications~~**

~~2.2.10.1.8 A display shall be provided to indicate when an equipment item has failed or is not operating within tolerance limits.~~

**~~2.2.10.2 Cables~~**

~~2.2.10.1.8 Cables shall be routed so as to be accessible for inspection and maintenance.~~

~~2.2.10.1.8 Cable routing shall not obstruct visual or physical access to equipment for operation or maintenance.~~

~~2.2.10.1.8 Cables shall be long enough so that required checking of any functioning item can be accomplished in a convenient place. Extension cables shall be provided where this is not feasible.~~

**2.2.10.2 Environmental Effects**

2.2.10.2.1 Equipment finishes and surfaces shall be designed to minimize glare and specular reflections.

2.2.10.2.2 The thermal design of workstations and equipment shall preclude "hot spots" (surface temperatures exceeding 45° ~~degrees~~ C~~elsius~~, 113° ~~degrees~~ F~~ahrenheit~~).

~~2.2.10.2.3 Radiation from CRTs or other devices shall not exceed government ANSI safety standards.~~

2.2.10.2.3 Computer peripherals and other equipment located in user areas shall not emit noxious (harmful or irritating) fumes or particulate matter.

~~2.2.10.2.4 Equipment finishes and surfaces shall be designed to have an aesthetically pleasing appearance.~~

**2.2.10.3 Human Computer Interface**

2.2.10.3.1 The Graphical User Interface (GUI) shall conform to the look and feel contained in the OSF/Motif Style Guide.

2.2.10.3.2 Displays and controls shall follow the user interface guidelines specified in the ~~**(DOC# - TBD)**~~ CLCS HCI Guidelines and Standards **(DOC# - TBD)**.

**Note:** The above referenced document contains guidelines and standards on many of the aspects of screen displays. For example:

1. Menues and Layout
2. User Inputs
3. Feedback to User
4. Status and Error Messages
5. Alarms and their management
6. Display Characteristics

**This note will be removed after ABR.**

~~2.2.10.3.3 The Graphical User Interface (GUI) shall conform to the look and feel contained in the OSF/Motif Style Guide.~~

~~**2.2.10.4 Menus and Layout**~~

~~2.2.10.3.3 Menus shall be ordered in such a way as to facilitate the usual procedures and natural work patterns of the user. For example, the most frequently used options should be placed first (or to the left) in the menu, and less frequently used options last.~~

~~2.2.10.3.3 All displays shall be consistent with respect to procedures and placement of information when these are common to more than one display.~~

~~2.2.10.3.3 Commands and prompts shall be clear, consistent, and unambiguous to a user.~~

~~2.2.10.3.3 Acronyms, message terminology, colors, and symbols shall be familiar and meaningful to users.~~

~~2.2.10.3.3 Edits to a data field which appears on more than one display shall only require input at one location and the change shall be replicated throughout the software automatically.~~

~~**2.2.10.4 User Input**~~

~~2.2.10.3.3 The user interface shall not require excessive motion and input activations to initiate necessary command/control functions (e.g. cross-screen mouse movement or multiple mouse click iterations for one operation).~~

~~2.2.10.3.3 The amount of input required by the operator to effect the necessary command and control functions shall be minimized.~~

~~2.2.10.3.3 The capability shall exist for a consistent method of using the input device to gracefully terminate, exit, or step out of an application.~~

~~2.2.10.3.3 Although the tracking device will likely be the primary input device, every operation that may be performed with a tracking device shall also have a keyboard equivalent.~~

~~2.2.10.3.3 If a command or control is potentially destructive or causes an irreversible action to be performed, it shall require confirmation from the user prior to execution.~~

~~**2.2.10.4 System Feedback to User**~~

~~2.2.10.3.3 Feedback shall be provided to the user indicating the acceptance or rejection of data entry and control initiation.~~

~~2.2.10.3.3 Error messages shall indicate the reason why a command is rejected.~~

~~2.2.10.3.3 A brief recommendation for resolution of the problem shall be provided unless space or other constraints prevent its practicality.~~

~~2.2.10.3.3 Notification shall be provided to the user of the potential hazard of functions that are pending execution (e.g., about to save over an already-existing file name).~~

~~2.2.10.3.3 The time lag between the response of a system to a control input and the display presentation of the response shall be minimized, consistent with safe and efficient system operation.~~

~~2.2.10.3.3 Visual indication and explanation to the user shall be provided if the response time, defined as the time from initial operator input to the time the desired change is complete, exceeds two seconds (e.g., "please wait – the system is processing").~~

~~**2.2.10.4 Status and Error Messages**~~

~~2.2.10.3.3 English language status and error messages shall be provided.~~

~~2.2.10.3.3 Status and error messages shall be brief and descriptive.~~

~~2.2.10.3.3 Status and error messages shall provide user-relevant facts about the problem and, where practicable, a means for resolving the problem.~~

~~2.2.10.3.3 Status and error messages shall be self-contained, and not require the use of an off-line reference manual. Cryptic messages (e.g., "error code 24") shall be avoided.~~

~~2.2.10.3.3 The use of abbreviations shall be limited, unless necessary and commonly known. When used, abbreviations shall be consistent throughout the system.~~

~~**2.2.10.4 Alarm Management**~~

~~2.2.10.3.3 All alarms shall be classified by severity type.~~

~~2.2.10.3.3 Alarm presentation shall be coded uniformly by alarm severity.~~

~~2.2.10.3.3 When auditory cues are used to convey alarm information, a redundant visually coded method shall also be employed.~~

~~2.2.10.3.3 When color coding is used to convey alarm information, another visually coded method shall also be employed.~~

~~2.2.10.3.3 Alarm messages shall provide descriptive but concise information about the anomalous condition.~~

~~2.2.10.3.3 The user shall have the capability to acknowledge or silence the audible alarm for which he/she has responsibility.~~

~~2.2.10.3.3 The user termination procedure for audible alarms shall be the same, regardless of the source or type of alarm.~~

~~**2.2.10.4 Display Characteristics (Color)**~~

~~2.2.10.3.3 Color shall not be the sole indicator of information coding. Another display indicator in addition to color must be provided to account for individual vision differences.~~

~~**2.2.10.4 Display Characteristics (Blinking)**~~

~~2.2.10.3.3 Blinking shall be used solely to indicate extreme conditions requiring immediate action or response by the user.~~

### 2.2.10.4 Command Panels

Command Panels are I/O devices that provide information to and receive ~~information~~ from Console Position users. Applications may display information to the Command Panel and accept discrete inputs from the users via Control Panel push buttons. All Console Positions which provide command and control capabilities, such as in the Operations Control Rooms (OCR) and Multi-function Rooms (MFR), must provide Command Panels.

2.2.10.4.1 The Command Panel shall provide the Safing functionality of the CCMS Programmable Function Panel (PFP).

2.2.10.4.2 The CLCS shall provide at all times a clear and unambiguous association between the Command Panel actions and the functions provided by the Command Panel buttons.

### 2.2.10.5 Operational Television (OTV)

Since the OTV system and the RTPS are separate systems ~~with no common elements~~ the only requirements in the CLCS for OTV are to provide space, power, and cooling in the Console Position equipment.

2.2.10.5.1 The RTPS~~CLCS~~ shall provide space, power, and cooling in the Console Position for TBD OTV displays.

2.2.10.5.2 The RTPS shall provide the capability after user test applications to command a specific camera to be selected for a specific OTV screen with preset position and zoom parameters.

### 2.2.10.6 I/O Devices

Each RTPS~~CLCS~~ Set contains ~~a~~ common I/O areas called ~~the~~ Shared I/O Areas that ~~is~~ are physically located in the vicinity of the user Consoles. There are two Shared I/O areas in each of the LCC OCRs that are isolated and on separate UPS power sources so that a single failure will not force a major interruption of operations.

2.2.10.6.1 Each~~The~~ Shared I/O Area shall contain one or more color page scanners, Fax machines, high quality black and white printers, color printers, and photo quality color printers.

2.2.10.6.2 The CLCS shall provide the capability to spool output from any Console Position to any of the output devices in the Shared I/O Area in that OCR.

2.2.10.6.3 The RTPS shall provide three separate shared I/O areas in each LCC Set OCR.

1. Operations support (2 ea)
2. Management row support (1 ea)

#### 2.2.10.7 Facilities

This section will contain facilities human factors requirements (e.g., lighting, humidity, floor covering, etc.)

### 2.2.11 SAFETY AND SECURITY REQUIREMENTS

#### 2.2.11.1 Safety Requirements

2.2.11.1.1 High voltage areas shall be clearly marked and shielded to prevent accidental contact.

2.2.11.1.2 High current power supply outputs shall be clearly marked and shielded to prevent accidental contact.

2.2.11.1.3 Safety covers shall be non-conductive if there is insufficient metering or adjustment clearances.

2.2.11.1.4 Power supplies shall be adjustable and measurable without removing safety covers.

2.2.11.1.5 All fans, gears, pulleys, and other moving parts shall be shielded and clearly marked.

2.2.11.1.6 Rack slides shall have safety catches to prevent over extension.

2.2.11.1.7 Doors and panels shall swing out of the working area or be removable.

2.2.11.1.8 If a sub-assembly must be moved to gain access during maintenance, troubleshooting, or repair of the system, it shall have restraining hardware to keep it secured and out of the way.

2.2.11.1.9 All laser devices shall be shielded and clearly marked.

2.2.11.1.10 All developed hardware shall be designed with receptacles “hot” and plugs “cold”.

#### 2.2.11.2 Security Requirements

2.2.11.2.1 The RTPS shall be physically isolated from all inbound communications other than those specified in section 2.1.1 External Systems Interface Requirements.

2.2.11.2.2 The CLCS shall provide a mechanism to prevent inadvertent issuance of commands from a console position or a local control device by an unauthorized system user.

2.2.11.2.3 The CLCS shall provide protection from malicious intrusion due to computer Software viruses.

2.2.11.2.4 The CLCS shall adhere to all agency and KSC specific security guidelines.

### 2.2.12 DESIGN AND CONSTRUCTION REQUIREMENTS

The design and construction requirements presented in this section address the system level general hardware design requirements for the CLCS . These requirements are imposed on the design of the system to maximize safety, reliability, commonality, maintainability, and usability. The design requirements and criteria specified in this section are applicable for all CLCS provided equipment.

#### 2.2.12.1 Underwriters Laboratory Certifications & Approval

2.2.12.1.1 Commercial equipment utilized in CLCS shall be compliant with either Underwriters Laboratory Specification 1950 or the International Equipment Consortium (IEC) Specification 950 for product safety.

2.2.12.1.2 Vendors shall provide the results of UL 1950 or IEC 950 compliance testing upon request.

### 2.2.12.2 Acoustics

2.2.12.2.1 The acoustical noise level of any subsystem shall comply with MIL-STD-1472.

### 2.2.12.3 Operating Environment

2.2.12.3.1 CLCS equipment shall operate within an ambient temperature of 10° C (50° F) to 32° C (90° F).

2.2.12.3.2 CLCS equipment shall operate within a relative humidity range of 20% to 80%, non-condensing.

### 2.2.12.4 Non -Operating Environment

2.2.12.4.1 CLCS equipment shall be designed to be stored within an ambient temperature of -17° C (0° F) to 49° C (120° F).

2.2.12.4.2 CLCS equipment shall be designed to be stored within a relative humidity range of 10% to 80%, non-condensing.

### 2.2.12.5 Altitude

2.2.12.5.1 No operational altitude requirements exist for CLCS, other than that CLCS equipment shall operate nominally in all currently identified deployment locations at KSC, JSC and DFRC.

2.2.12.5.2 CLCS equipment shall be capable of operating normally, after being subjected to basic transportation as secured cargo by land, sea or air.

### 2.2.12.6 Temperature

2.2.12.6.1 R~~R~~ack-mounted CLCS equipment shall operate with a forced air temperature between +60° and +80~~75~~° F as measured at the air input at the base of the rack with extremes of uncontrolled temperatures between 52° and 105° for one (1) hour.~~.~~

2.2.12.6.2 Rack-mounted CLCS equipment shall operate with a temperature rise not exceeding 18° F as measured between the air input at the base of the rack and the air output at the top of the rack.

2.2.12.6.3 Non-rack-mounted equipment (DDP, CCP, Workstations, etc.) shall be designed to operate in an air conditioned environment with the ambient room temperatures between +60° to +80~~90~~° F with extremes of uncontrolled temperatures between 52° and 105° for one (1) hour.

2.2.12.6.4 ~~.~~

### 2.2.12.7 Physical Power

2.2.12.7.1 CLCS equipment utilizing 115 VAC power shall be plugged into rack-resident Power Distribution Panels (PDPs) where feasible.

2.2.12.7.2 The CLCS PDPs shall be plugged into 208 VAC 3-Phase underfloor facility power with NEMA-style L21-30P or L5-30P connectors.

### 2.2.12.8 Operating Supply Voltage

2.2.12.8.1 CLCS equipment utilizing 115 VAC power shall operate normally within the ranges of 100 VAC to 130 VAC and 57HZ to 63Hz.

2.2.12.8.2 CLCS equipment utilizing 208 VAC power shall operate normally within the range of 200 VAC to 230 VAC.

**2.2.12.9 Grounding**

All CLCS equipment shall be referenced (via the green safety ground wire in its power plug) to the single-point ground in the facility where they are installed.

2.2.12.10 **Electromagnetic Interference**

2.2.12.10.1 Commercial equipment utilized in CLCS that is sold in the United States shall be compliant with FCC Class A specifications for electromagnetic emissions.

2.2.12.10.2 Custom-designed equipment utilized in CLCS will be subjected to MIL-STD-461/462 testing to identify potential electromagnetic compatibility problems. (See Electromagnetic Compatibility below.)

**2.2.12.11 Electromagnetic Compatibility**

NOTE: Electromagnetic interference is highly dependent upon the facility where the equipment is located, the orientation of the equipment, communication frequencies and many unpredictable factors. Prior to the turnover of all CLCS sets of equipment, EMI emissions checks will be performed on-site to identify any potential problems that exist. If deemed appropriate by engineering judgment, common EMI preventative measures (gasketing, fingerstock, in-line filters, ferrules, etc...) will be employed to reduce or alleviate the problem.

**2.2.12.12 Electrostatic Discharge**

2.2.12.12.1 Each rack-mounted subsystem shall withstand an electrostatic discharge of 12.5 kilovolts through 280 picofarads and 600 ohms on any exterior cabinet surface with no loss of data integrity within the system or subsystem.

**2.2.12.13 Protective Coatings and Finishes**

2.2.12.13.1 Commercial equipment utilized in CLCS that is sold in the United States shall use protective coatings and finishes in accordance with the suppliers standard commercial practices.

2.2.12.13.2 Commercial equipment with deficiencies in its protective coatings (i.e. an unpainted aluminum housing) shall be disqualified for use in CLCS

2.2.12.13.3 Custom-designed equipment used in CLCS that contains bare aluminum shall have that aluminum treated per MIL-STD-171, Class 1A, finish 7.3.3 (irridite).

2.2.12.13.4 Custom-designed equipment used in CLCS that contains bare steel shall have that steel treated per ASTM specification B633, SC2, type II (zinc-plated).

2.2.12.13.5 All painted surfaces shall utilize primers and high-quality enamel or latex paints.

2.2.12.13.6 The actual colors employed, shall be based upon FED-STD-595. (The colors will be identified by the CLCS Human Factors Team and approved by the CLCS Design Panel and the User Community).

2.2.12.13.7 No wood-based or other flammable materials shall remain exposed in CLCS subsystems or equipment.

**2.2.12.14 Dissimilar Metals and Corrosion Control**

2.2.12.14.1 Metal parts utilized in CLCS equipment shall be treated (per MIL-STD-171) to resist corrosion if they are to be used with other (dissimilar) metals.

#### 2.2.12.15 Fungus Resistance

2.2.12.15.1 Where feasible, materials used in the construction of commercial and custom-designed CLCS equipment shall be either fungus resistant or treated to resist fungus.

2.2.12.15.2 Commercial equipment that is susceptible to fungus and cannot be made fungus resistant shall be disqualified for use in CLCS.

#### 2.2.12.16 System Cable Numbering

2.2.12.16.1 System cables utilized in CLCS will receive a “W” identifying number that uniquely identifies each cable.

2.2.12.16.2 All system cables will be identified in the appropriate CLCS cable interconnect diagram(s).

#### 2.2.12.17 Serialization and Bar Code Labeling

For accountability and traceability purposes, each unique classification of equipment (assembly number or specification number) used in CLCS that is valued over $250 will be assigned a unique serial number.

2.2.12.17.1 For commercial equipment, the rules specified in KSC NHB 4200.2 shall apply.

# 2.3 BUSINESS AND INFORMATION NETWORK REQUIREMENTS

The Business and Information Network (BIN) provides RTPS workstation connectivity and access to non-RTPS applications and data such as Orbiter cable and connector information, E-Mail, documentation, drawings, etc. Refer to Table **TBD-BELOW** for the supported external applications and their function. Access to these applications and their information is provided via computing resources in the CLCS that are available at the Console Position.

## 2.3.1 BUSINESS AND INFORMATION NETWORK

2.3.1.1 The Business and Information Network shall provide access to external systems via a network separate from the Command and Control Network.

2.3.1.2 The Business and Information Network shall provide the software tools necessary to retrieve, display, update, and print information available on external computing systems.

2.3.1.3 The Business and Information Network shall provide the following office capabilities.

1. Word Processing
2. Spread Sheet
3. Drawing Tool

**Rationale:** There is a variety of computing systems at KSC and other NASA centers that contain information of value to personnel in the OCRs. Access to this data in a timely manner will help to minimize the labor force required to checkout and launch the Space Shuttle. The following kinds of information will be available from the external systems:

| External Element | Function |
|---|---|
| E-Mail | Communication |
| Expert Systems (e.g., KATE, PSA, DLES, IAPU) and Integration Tools | |
| FTP | File Transfers |
| Goody Books | |
| IWCS | |
| JSC | |
| KEDS | Electronic Drawings |
| LANs | |
| MFSC | |
| OMI | Operations/Maintenance Instructions |
| Operations Notes | |
| PCGOAL | Monitor Displays |
| PRACA | Problem/Correction Information |
| SCAN | Cable and Connector Information |
| SDC | Retrievals |
| SDS | Monitor Displays |
| SECAS | |
| SIMS | Pictures |
| System Help | |
| X-Term | Terminal Emulation |
| WWW/Internet | |

## 2.4 SHUTTLE DATA CENTER REQUIREMENTS

The SDC is the portion of the CLCS that provides off-line processing for the CLCS. It is used to prepare software for use in the CLCS, to store data which has been processed by the RTPS, and provide a retrieval capability for the data that has been previously stored. This system is similar to the CDS in the LPS.

The SDC is a local area network interconnected through standard communications protocol. Several of these servers are designated as SDC Application Servers (SASs). These servers provide support of COTS products used by CLCS Support Software, and Development Environment capabilities. In addition, one or more of the SASs are configured as a HyperText Transfer Protocol (HTTP) Server to support access to CLCS Support Software functions from HyperText browsers such as Mosaic

Within the SDC local area network, a server is designated as the CLCS Test Build Server (CTB). This server hosts CLCS Test Build Software within the SDC. This server provides support of COTS products used by CLCS Test Build Software.

### 2.4.1 SHUTTLE DATA CENTER

2.4.1.1 The SDC shall provide access to COTS products used by CLCS Support Software.

2.4.1.2 The SDC shall provide access to Development Environment capabilities necessary for supporting day to day development operations.

2.4.1.3 The SDC shall provide access to CLCS Support Software via Hyper-Text Transfer Protocol.

2.4.1.4 The SDC shall provide access to the CLCS Test Build Software.

### 2.4.2 TEST BUILD

The CLCS provides a means of supporting test definition, test build, load, and activation , similar to the ‘System Build’ functions in LPS, of a Target CLCS Set that has been loaded with a System Build load.

2.4.2.1 The CLCS shall provide a central repository of Function Designator information.

2.4.2.2 The CLCS shall provide a means of managing the Function Designator data housed in the repository.

2.4.2.3 The CLCS shall provide a means of defining the criteria for the selection of data to be included in the test load.

2.4.2.4 The CLCS shall provide a temporary repository to contain the data selected for inclusion in the test load.

2.4.2.5 The CLCS shall provide a means of building the data loads required by the RTPS, such as Gateway table, Online Data Bank, Fusion tables, etc.

### 2.4.3 SYSTEM/APPLICATION BUILD AND CONFIGURATION MANAGEMENT ENVIRONMENT

The CLCS must provide the capability to develop and manage System Software, and Application Software for use in the RTPS and SDC. This capability must adequately control software throughout its development life cycle including, but not limited to, version and release management. This process, commonly referred to as Configuration Management (CM), must be capable of handling and storing all of the products needed to define and build the CLCS.

2.4.3.1 The CLCS shall provide the capability to develop and manage code as specified in the following table:

| Function | C & C++ | | | | |
|---|---|---|---|---|---|
| Create Source Code | Y | | | | |
| Edit Source Code | Y | | | | |
| Compile Source Code | Y | | | | |
| Link into Load Files | Y | | | | |

| Function | C & C++ | | | | |
|---|---|---|---|---|---|
| | | | | | |

2.4.3.2 The CLCS shall provide the capability for storing and archiving multiple versions of any file in a permanent repository (CM Repository).

2.4.3.3 The CLCS shall provide a CM Repository capable of promoting and drawing down Configuration Managed files.

2.4.3.4 The CLCS CM System shall provide reports on.

1. Files contained in various libraries.
2. Release documentation (e.g., PR, CR, Modules in release, version numbers, etc.).

2.4.3.5 The CLCS shall provide the capability to build, and release, single and Synchronized Subsystem Load Files for use in the operations and debug environments.

2.4.3.6 The CLCS shall record the all activities occurring in the CM system.

### 2.4.4 RECORDING

2.4.4.1 If the computer has the capability to source data to a network which may be recorded, then it must have access to time accurate to within 100 microseconds for the purpose of time-stamping.

2.4.4.2 All application to application communications should be made through the network even though the two may be on the same physical computer for recording purposes.

2.4.4.3 Provide the capability for a user to record the occurrence of each ‘instruction’ in a automated sequence application

2.4.4.4 Microphones are not required for early CLCS, but should be provided in later releases to allow voice recording of dedicated messages and observations during testing.

2.4.4.5 The system shall record user actions that potentially result in changes to the state of the system (included but not limited to perform program, send command, answer program prompts, PFP presses, program text information, messages, and voice dictation).

2.4.4.6 The system should allow the user to perform a CRT screen capture, have it time-stamped, and recorded/logged.

2.4.4.7 Provide the capability for test equipment data to be monitored and recorded with CLCS data or locally local to the TEI.

2.4.4.8 Provide a single centralized record and retrieval capability.

2.4.4.9 Provide recording of all measurement changes, messages, time, configuration data and commands.

2.4.4.10 Inter-process communication between test/control applications must be recorded on the centralized recording system (SDC).

2.4.4.11 Selected keyboard and mouse actions must be recorded on the centralized recording system (SDC).

2.4.4.12 Exception notification to a responsible system must be recorded.

2.4.4.13 Time tag all data to within 100 microseconds for recording purposes. (To support 6K SPS valve signature and 600 microsecond LDB data.)

**2.4.4.14** Provide the capability for test applications to log messages (BFL equivalent) either locally or to the recording system.

2.4.4.15 Record the measurement status word updates.

**2.4.4.16** All configuration information should be recorded**.**

**2.4.4.17** Redundancy should exist for the recording subsystem in SDC.

2.4.4.18 All access attempts will be logged for traceability.

**2.4.4.19** Provide the capability for test applications to log messages (BFL equivalent) either locally or to the recording system**.**

**2.4.4.20** Available to the system and applications, local logging of messages on the computer's local storage. This is a round-robin area which should hold XX hour(s) worth of messages. This area can optionally be archived to SDC should it become necessary**.**

2.4.4.21 Available to the system and applications, remote logging of messages to SDC directly with an indication of whether the data should be keep short-term or long-term for retrievals. (Short term data should nominally be kept for XX days.)

**2.4.4.22** Available to the system and applications, local logging of messages on the computer's local storage. This is a round-robin area which should hold XX hour(s) worth of messages. This area can optionally be archived to SDC should it become necessary**.**

2.4.4.23 Provide a screen capture and archive capability.

### 2.4.5 RETRIEVING

2.4.5.1 Provide the capability for test/control applications to retrieve near-real-time data.

**2.4.5.2** The business and information CPU will allow user access to SDC for retrievals**.**

2.4.5.3 Provide a single centralized record and retrieval capability.

**2.4.5.4** The retrieval system will have an SQL I/F capability.

2.4.5.5 Available to the system and applications, remote logging of messages to SDC directly with an indication of whether the data should be keep short-term or long-term for retrievals. (Short term data should nominally be kept for XX days.)

### 2.4.6 ARCHIVING

## 2.5 SIMULATION SYSTEM REQUIREMENTS

*[Note for inclusion in this section when it is filled out — data should be supplied to the gateway in raw counts (same as today), also in whatever format is decided upon when the simulation stream is introduced into the RTCN. There is also a requirement to provide network traffic simulating gateway outputs.]*

The Simulation system is the portion of the CLCS that provides support for the testing and validation of CLCS equipment, checkout and validation of procedures used in Shuttle ground testing and launch operations, training of CLCS console operators, and launch team training. The Simulation system supports the creation, modification, test, maintenance, and operation of mathematical models of Shuttle and GSE systems which simulate the ground equipment, Orbiter functions and computers, the ET, SRBs, and payload protocols.

### 2.5.1 SIMULATION SYSTEM

2.5.1.1 The Simulation system shall support the compilation of math models and associated model control procedures (MCPs).

2.5.1.2 The Simulation system shall support, the execution, testing, and checkout of models and MCPs.

2.5.1.3 The Simulation system shall support execution and interfacing models to the CLCS, in the real-time mode of operation to provide:

1. Testing and validation of CLCS Application software
2. Checkout and validation of test procedures (i.e., both manual and automated)
3. Launch team training
4. CLCS equipment check-out

### 2.5.2 SIMULATION SUPPORT

The Simulation system must provide the capability to deliver simulation support for both integrated and non-integrated testing. In addition to integrated simulation training support, simulation support must be provided to the office environment for development of user displays and test applications.

2.5.2.1 The Simulation system shall provide network access to a simulation engine from the office environment.

2.5.2.2 The Simulation system shall provide a simulation capability that supports multiple (i.e., ??? number) users simultaneously for developing user displays and test applications.

### 2.5.3 SIMULATION CONNECTIVITY

The Simulation system must support connection of the SGOS models to provide for testing through the gateways (e.g., LDB Gateway, GSE DB Gateway, PCM Uplink, and PCM Downlink) in addition to supporting the connection of models to the RTCN without using the VSI.

2.5.3.1 The Simulation system shall provide the capability of connecting the SGOS models to the Video Simulation Interface (VSI).

2.5.3.2 The Simulation system shall support the connection of the SGOS models to the CLCS RTCN without the use of front end gateways or the VSI.

2.5.3.3 The Simulation system shall provide one each Simulation Gateways for a connection to 2 SDEs and 1 IDE (i.e., 3 Gateways).

2.5.3.4 The Simulation system shall provide a network or equivalent interface between SGOS simulation and the Simulation Gateway.

2.5.3.5 The Simulation system shall provide for the conversion of GSE, PCM, and SSME measurement values to Gateway Change Packet formats.

2.5.3.6 The Simulation System shall provide for the stimulation of the model GSE Analogs and Discrete stimulus values by way of the CCP Command Request Packet(s) from the RTCN.

### 2.5.4 SIMULATION EXECUTION

The Simulation system must provide support for execution of the Math Models in both the real-time and terminal modes of operation.

#### 2.5.4.1 Simulation Execution in Real-time

TBD

#### 2.5.4.2 Simulation Execution in Terminal Mode

In the terminal mode of operation, the capability for controlling Math Model operation must be provided.

2.5.4.2.1 The Simulation system shall parse all current SGOS Terminal Control Statements as defined by KSC-LPS-SGOS-5200 Document, Section 3.

2.5.4.2.2 The Simulation system shall convert the functionality of the Terminal Control Statements to C executable by the Executive.

2.5.4.2.3 The Simulation system shall access I-file data created at build time to verify correct usage of variable names.

2.5.4.2.4 The Simulation system shall perform all error checking described in KSC-LPS-SGOS-5200 Document, Section 3.

### 2.5.5 SIMULATION DEVELOPMENT AND PRODUCTION ENVIRONMENTS

The Simulation system consists of two environments (i.e., a Simulation Development Environment (SIMDE) and a Simulation Production Environment). Service to both environments is provided by each of the Simulation Build and Repository Server, the Simulation Source Server, and the Target Compile Server. These servers provide support of COTS products used by Simulation Development and Production Environment capabilities.
Within the simulation local area network, a server is designated as the Simulation Build and Repository Server. This server provides for the hosts Simulation Build Software within the Simulation System. This server provides support of COTS products used by Simulation Build software.

2.5.5.1 The Simulation system shall provide access to COTS products used in the Simulation Development and Production Environments.

2.5.5.2 The Simulation system shall provide access to simulation development environment capabilities necessary for supporting day to day simulation development operations.

2.5.5.3 The Simulation system shall provide access to the Simulation Build Software.

## 2.5.6 SIMULATION TRANSLATION AND COMPILE

The Simulation system must provide the capability of utilizing the existing SGOS Math Model and Procedure baseline.

### 2.5.6.1 SGOS Math Models

The Simulation system must provide the capability of translating existing SGOS Math Models to C and provide for subsequent successful compilation.

2.5.6.1.1 The Simulation system shall parse complete SGOS modeling language syntax.

2.5.6.1.2 The Simulation system shall generate a converted model source in C with model segments represented by C functions.

2.5.6.1.3 The Simulation system shall access model databank information in order to verify correct model variable usage.

2.5.6.1.4 The Simulation system shall generate model variable cross referencing information to be used by Model Build.

2.5.6.1.5 The Simulation system shall generate a list of model subsystems called by model to be used by Model Build.

### 2.5.6.2 SGOS Model Control Procedures

The Simulation system must provide the capability of translating existing SGOS Model Control Procedures to C and provide for subsequent successful compilation.

2.5.6.2.1 The Simulation system shall parse all current SGOS Model Control Statements as defined by KSC-LPS-SGOS-5100 Document, Section 4.

2.5.6.2.2 The Simulation system shall generate a converted procedure source in C executable by the Executive.

2.5.6.2.3 The Simulation system shall access model databank information in order to verify correct usage of databank names.

2.5.6.2.4 The Simulation system shall perform all error checking described in KSC-LPS-SGOS-5100 Document, Section 4.

2.5.6.2.5 The Simulation system shall generate a list of procedures called by the source procedure to be used by model build.

## 2.5.7 SIMULATION BUILD

The Simulation Build must provide the capabilities to pull the system Math Models from either of APLM or user files and build Master Models to support specific TCIDs.

2.5.7.1 The Simulation Build shall accept as input the model variable cross referencing information and list of model subsystems.

2.5.7.2 The Simulation Build shall integrate Master Model with subsystems.

2.5.7.3 The Simulation Build shall support infinite levels of model subsystems.

2.5.7.4 The Simulation Build shall provide model segment ranking functionality.

2.5.7.5 The Simulation Build shall access flight formats file for PCM formats.

2.5.7.6 The Simulation Build shall access FD directory for FD hardware information.

2.5.7.7 The Simulation Build shall generate tables required by model executive.

2.5.7.8 The Simulation Build shall generate tables required to interface to VSI.

2.5.7.9 The Simulation Build shall generate integrated executable for Master Model for specified hardware.

# 3. PROBLEM BLUE BOOK REQUIREMENTS

## 3.1 REQUIREMENTS DRIVING COST

| | |
|---|---|
| **Advisory Systems** | [2.3.17.60] CLCS will provide access to expert systems such as KATE, PSA, DLES, and IAPU from the business and information position. |
| **CCS Set** | Many CCS Requirements should be moved to the Launch Control Center Set. |
| **Generic Console** | [2.3.5.7] Hardwire safing will be implemented in a manner which allows the consoles to remain 'generic'. |
| **Mini-cameras** | [2.3.17.21] Mini-cameras are not required for early CLCS, but should be provided in later releases to allow video-teleconferencing. |
| **Operational TV** | [Various] CLCS requirements to integrate OTV into the CLCS. |

## 3.2 REMOVED REQUIREMENTS

This section contains a list of the requirements that were removed from the Blue Book requirements by the SLS Design and User Liaison Team. The requirements number from the Blue Book is preserved for ease of identification and enclosed in brackets [ ]. Requirements in the Blue Book that were merged with other similar requirements are not listed here. Likewise, requirements that were dropped in reaction to a comment that stated "Remove this requirement" are not listed. The list contains only those requirements that were likely to be issues or those that needed extra visibility to the user community. In each case a short rationale statement is included to indicate why the requirement was removed.

[2.3.5.5] Provide additional $LO_2$/$LH_2$ safing to be able to drain the ET via hardware

**Rationale:** This requirement requires changes to the Orbiter. It can not be performed by CLCS alone. The requirement should be forwarded to the Orbiter Upgrade Project.

[2.3.11.6] Limits should be given names and a facility to predefine some of them and have them placed in the data bank should be available.

**Rationale:** Setting limits in the data bank for CCMS system has not proven to be a beneficial capability. The labor and time necessary to change data in the data bank and then edit or rebuild a TCID is prohibitive. A simplified approach is to create an application that sets the limits for a given set of measurements at the time that the measurements achieve compatible values (e.g., after a power supply has been powered up and stabilized it is appropriate to set the limits you wish to monitor and start monitoring them).

[2.3.17.10] PFPs will be provided at each command and control position.

[2.3.17.11] The PFP will be logically associated with the application running in the active window of the command and control CRT. This will be true even if the keyboard is switched to the business and information CRT at the position.

[2.3.17.12] The PFP will provide push-buttons to select functions.

[2.3.17.13] The PFP need not display currently active application names, but another means (task bar, etc.) will be provided to encompass this functionality.

**Rationale:** All four of the PFP requirements were removed because the Console Design Team is attempting to get the PFP requirement deleted from the program. **Note:** There is also a PFP requirement in the Human Factors section. One or the other set of requirements must be removed before the final version of this document is published.

# Appendix A. — GLOSSARY

Active — A term used to describe one of the subsystem computers in an Active/Standby pair that is currently performing its intended function.

Application — An application is a computer software program, or set of programs, written to perform a specific task (e.g., MS Word, MS Power Point, CCMS Ground Launch Sequencer). There are two different categories of applications in CLCS — Systems Applications and User Applications.

Application Debug Configuration — A standalone workstation configured with multiple subsystem loads which may be used to debug application software without support from networks or the Simulation Subsystem.

Backup — A subsystem that can be used as a replacement for one of the pair of Active/Standby subsystem computers in the event of a failure. Manual activity is required to bring the backup subsystem online (i.e., the backup system is not maintained in a "hot" standby role).

Business and Information Network — The Business and Information Network is a network of communications paths, computers, computer programs, and information that are external to the CLCS. The CLCS provides connectivity and access to this external network.

Bypass — **Rick Dawson please supply.**

Calibration - Calibration is the process of converting the digital representation of an analog measurement that has been acquired from a sensor to a floating point value that represents the calibrated engineering units of the measured quantity (e.g., pounds of pressure per square inch, temperature, speed, etc.). Sensors convert the measured quantities to an electrical voltage (an analog signal) which is subsequently converted to a digital quantity by an analog to digital converter (ADC). Sensors may introduce non-linearities into the measured quantities due to the physics of the measuring device. If the voltage output of the sensor has a linear relationship with the pressure measured by the sensor, engineering units can be calculated by the linear equation.

> Measurement Value = m * voltage + b, (where m is the slope of the line and b is the voltage value when the pressure is equal to zero.)

For non-linear signals a polynomial is required to convert the voltage value to the equivalent pressure value. An $n^{th}$ order polynomial, of the form below, is used to make this conversion:

> Measurement Value = $\mathbf{a_n x^n + a_{n-1} x^{n-1} + \ldots + a_1 x^1 + a_0}$, (where x represents the sensor voltage)

Calibrated Measurement Data — Analog data which has been converted to engineering units and calibrated by applying the calibration coefficients.

Cargo Integrated Test Equipment Set (CITE) — The Cargo Integrated Test Equipment Sets are located in the Space Station Processing Facility (SSPF) and Vertical Processing Facility (VPF) and are used to integrate and test payloads prior to them being loaded into the Orbiter.

CCMS Set — The set of equipment used to control and monitor end items using the CCMS. See table A-1 for a list of CCMS Sets.

CDBFR Counts — CDBFR counts are count values resident in the CDBFR. These counts are left justified within the CDBFR word. All CDBFR counts are assumed to be linear, bipolar, 2's complement, big-endian integer values. CDBFR count values can be up to 16-bits long. This terminology is new and is introduced to clarify the distinction between right justified processed counts and left justified CDBFR counts.

CDBFR Length — The CDBFR length of a measurement is the number of CDBFR bits required to represent the measurement in CDBFR counts. For example, the CDBFR length of an 8-bit unipolar GSE measurement is 9; 1 sign bit plus the 8 unipolar magnitude bits (remember that CDBFR counts are always assumed to be bipolar, thus a sign bit must be added to unipolar measurements by the FEP). The CDBFR length of a 10 bit bipolar PCM measurement is 10; the sign is already part of the raw data and does not have to be added. CDBFR lengths range from 2 to 32 bits. Since the CCMS CDBFR uses 16-bit words, any measurement with a CDBFR length > 16 requires two CDBFR locations

CDBFR Size — The CDBFR size of a measurement is the total number of CDBFR bits being used to hold the measurement. In CCMS, single word analogs (AM) reside in a single CDBFR location, thus the CDBFR size is 16. Multi-word analogs (AMDP) reside in two CDBFR locations, thus the CDBFR size is 32.

Calibrated Engineering Units (CEU) — See Calibrated Measurement Data.

Checkout and Launch Control System (CLCS) — The Checkout and Launch Control System is the replacement for LPS and is composed of a Real-Time Processing System, Shuttle Data Center, Simulation System, and a Business and Information Network.

Checkout and Launch Control System (CLCS) — The Checkout and Launch Control System is the replacement for LPS and is composed of a Real-Time Processing System, Shuttle Data Center, Simulation System, and a Business and Information Network.

CLCS Shuttle Data Stream (SDS) — The CLCS Shuttle Data Stream is the CLCS equivalent of the CCMS Shuttle Data Stream.

Command Panel — Command Panels are Input/Output (I/O) devices that provide information to and receive manual inputs from Console Position users.

Common Data Buffer — A shared memory that contains the current status of all measurement data and subsystems in a CCMS set. The CDBFR also provides allows transmission of all messages in a CCMS set.

Common Equipment Area (CEA)— The Common Equipment Area is the back room of the OCRs and MFR and contains the Control Groups (CCP, DDP), Gateway Groups, and network equipment for the Launch Control Center Set.

Complex Control Set (CCS) — The Complex Control Set is located in the LCC at the Kennedy Space Center. It is used to monitor and control facilities equipment at KSC.

Computer Software Configuration Item (CSCI) — An aggregation of software that satisfies an end use function and is designated for separate configuration management by the acquirer. CSCIs are selected based on tradeoffs among software function, size, host or target computers, developer, support concept, plans for reuse, criticality, interface considerations, need to be separately documented and controlled, and other factors.

Configuration Item (CI) —An aggregation of hardware, software, or both that satisfies an end use function and is designated for separate configuration management by the acquirer.

Configurable Set **--- Placeholder**

Console — This term is used exclusively to describe the three-bay housing in the CCMS LPS system.

Console Back Row — This term is used exclusively to describe the CCMS set of MODCOMP computers, tables and PCGOAL workstations that reside behind the Consoles in the CCMS LPS system.

Console Position — The CLCS Console Position is a generic term used to refer to all the necessary workstations, hardware, peripherals and connectivity required (e.g., OIS-D, OTV, Safing, Applications Software Access, Business Systems Access, etc.) to support any the human interface to the RTPS.

Console Support Module — A CLCS Console Support Module provides the necessary table space, hardware and connectivity to allow additional users to comfortably support operations taking place at a CLCS Console Position.

Constraint Management — The capability to monitor measurement and fused data for a predetermined condition and notify personnel operating the Test Set and other software applications executing within the Test Set that the monitored data no longer meets the predetermined condition.

Control Group — A physical set of hardware consisting of Data Distribution Processors and Command Control Processors connected together along with the associated Real-Time Critical Network and Display and Control Network equipment.

Controlling — A term used to describe a software process that is currently actively monitoring and managing a set of hardware or software resources. The process normally has a second copy of itself that is executing in a separate CPU and monitoring the activities of the controlling process. On command, this second copy will assume control of the resources

Converted Counts — Converted counts are raw counts that have undergone subtype-dependent processing in the FEP to isolate and position count data within a data word. Examples of subtypes that require processing are Binary Coded Decimal (BCD), TACAN Bearing (TAB), BIT String Magnitude (ASM), and Halfword Overflow Signed (AOS). Other than the fact that converted counts have had some “conversion processing” performed, these counts are similar to raw counts, i.e., they are right justified, bipolar, 2’s complement, big-endian integer values. This terminology is new and is introduced to clarify the distinction between right justified raw counts and right justified processed counts.

Data Fusion — Data fusion is the process of combining measurement data and other CLCS system parameters into a higher level of information. The process for combining data may include algebraic and logical manipulation of data and conditional testing of system parameters or intermediate calculated values. The combined or "fused" data is a CLCS function designator.

Data Health — The combination of gateway status for each item of data and user defined status for the data item.

Data Status — The portion of data health that relates strictly to the status of the data item as determined by the gateway (e.g., a measurement who's status indicates it isn't being updated because it isn't in the current PCM format).

Data Validity — Data Validity is a term used to describe whether or not measurement data is valid at a given point in time. Many of the measurements acquired from the Flight Vehicle are not present in all PCM formats and thus the value of the measurement is either not known or the last known value is no longer valid.

Delivery – An incremental deployment of CLCS development consisting of facilities preparation, hardware, and software.

Delivery Theme – The primary driving force for determining the capabilities to be deployed in a CLCS delivery.

Derived Measurement — A Derived Measurement is one whose value is created within the RTPS. A Derived Measurement may be either a Data Fusion FD or a Pseudo FD.

Development Set — **Placeholder**

Direct Command — A command to the End Item Manager to disable closed loop control of a function and allow issuance of a command to the end item itself.

Display Synchronous Rate (DSR) — The time period between packets from Data Distribution on the DCN.

Dryden Flight Research Center (DFRC) Set — The Dryden Flight Research Center Set, located at Edwards, California, is used to monitor and control the Orbiter during landing operations.

Endian Architecture — When several bytes are required to store data, computers differ in which byte of storage they consider to be the "first". In "right-to-left" or "little-endian" architecture, which include the Intel 80x86 and Pentium microprocessor, the address of a 32-bit integer is also the address of the low-order byte of the integer. In "left-to-right" or "big-endian" architectures, which include the Motorola 680x0 microprocessor family, the address of a 32-bit integer is the address of the high-order byte of the integer. Consider the number 1234 that is stored in addresses a through a+3:

| | | | | | |
|---|---|---|---|---|---|
| Big-endian, left-to-right | 01 | 02 | 03 | 04 | The number is stored left to right |
| | a | a+1 | a+2 | a+3 | |
| Little-endian, Right-to-left | 04 | 03 | 02 | 01 | The number is stored right to left |
| | a | a+1 | a+2 | a+3 | |

End Item — The set of actuators, transducers, software and equipment that are controlled by CLCS. This term is used to indicate both the lowest level of end item (e.g., a valve) and the collection of end items that constitute a larger end item (e.g., APU, Orbiter, Payload, Facilities Equipment).

End Item Manager — The software used to implement closed loop control of End Items within CLCS.

Engineering Units — Engineering units are the representation of the measurement in the units understood by the user (e.g., volts, PSI, feet per second, etc.). Floating point numbers are used to represent engineering units. The engineering unit range depends on the type of hardware transducer.

Flight Vehicle — The term used to refer to the Orbiter, External Tank and Solid Rocket Boosters; this term does not also refer to the Payload.

Flow Zone — A collection of console positions configured to support a particular test. Within an OCR, one or more flow zones can exist and will fluctuate according to the test configurations.

Focal Thread — Each CLCS delivery will have one to two focal threads that are used to integrate work from multiple system threads. Taken together, the focal threads provide the delivery theme capability and normally focus on the user.

Forward Link Mode — A mode in which the RTPS PCM Uplink can operate, in which data is transmitted at 128 Kbs to the Orbiter Communications Interface Equipment (CIE) via the ground Communications and Tracking (C&T) station.

Fractional Counts — Fractional counts are a floating point “interpretation” of CDBFR counts that assumes an implied binary point exists to the right of the sign bit. Mathematically, then, fractional counts range from -0.5 to +0.5. CCMS console software converts CDBFR counts to fractional counts prior to scaling.

Function Designator — Function Designator is the name given for an item which is defined externally to where it is used. This term is slightly different between CCMS LPS and CLCS. The two definitions follow:

1. LPS — A Function Designator identifies by name items which are external to a GOAL procedure. Function Designators are normally defined in the data bank and refer to hardware measurements, commands, or system elements. However, some FDs are defined in GOAL procedures for use as a Pseudo Parameter of a program.
2. CLCS — A Function Designator is a name given to items which are defined in one place, such as the data bank, and may be referred to anywhere within the CLCS System.

Function Designator Data — The set of data relating to a function designator. The data consists of FD Value (i.e., Converted Counts, Calibrated Engineering Units), FD Health, FD Time of occurrence, and Display Attributes.

Gateway Group — The collection of Gateways which are physically linked to a particular physical area (e.g., Pad A, OPF 1, etc.).

Hardware Configuration Item (HWCI) — An aggregation of hardware that satisfies an end use function and is designated for separate configuration management by the acquirer.

Hot Standby — An on-line resource ready to be configured to serve as a replacement for another resource.

Hypergol Maintenance Facility (HMF) Set — The Hypergol Maintenance Facility Set is located in the industrial area at the Kennedy Space Center. The HMF Set is used to monitor and control Hypergolic equipment from the Orbiter that is being reconditioned and refurbished for reuse.

Integrated Development Environment (IDE) Set — The Integrated Development Environment Set is located in the LCC at the Kennedy Space Center. The IDE is used for integration and test of the CLCS Application Software with released CLCS Hardware and System Software.

Inter-Range Instrumentation Group (IRIG-B) — **Placeholder**

Intrusive — Any process or event which will significantly alter the normal configuration or operation of a operational, on-line CCMS or RTPS resource.

Kennedy Avionics Test System (KATS) Set — The Kennedy Avionics Test System Set is located in the VAB at the Kennedy Space Center and is used to provide limited avionics test and simulation capability without utilizing the larger Shuttle Avionics and Integration Lab at the Johnson Space Center. KATS also supports procedure development and, in a limited capacity, pre-installation flight element LRU checkout.

Launch Control Center (LCC) Set — The Launch Control Center Set consists of all of the RTPS equipment located in the OCRs, CEA, MFR of the LCC at the Kennedy Space Center. This equipment may be configured into subsets or supersets to accommodate tests requiring varying RTPS resources to support appropriate End Items.

Launch Data Bus Monitor (LDBM) — A collection of equipment used to record all message traffic on the LDB and GSE data busses.

Linearization — Signal non-linearities are introduced into analog measurements by signal conditioners and transducer non-linearities. The CCMS system assumes that the analog data, which is stored and processed from the CDBFR, exhibits a linear relationship between the signal (in counts) as recorded in the CDBFR and the actual signal fluctuation as measured by the transducer. A method of accounting for this non-linearity was implemented in LPS. The capability was provided to associate line segment approximations of the calibration data curve with an analog measurement. The linearization curve is approximated by the use of one or four line segments. Each line segment has a K1 (slope) value and a K2 (Y-intercept) value which constitutes the standard equation for a line.

Local Operations — Local Operations are those that are performed in the vicinity of the actual hardware.

Logged Data — Data that is sent to the recording system to be recorded. This data is equivalent to Block Funnel Logged (BFL) data in LPS.

Measurement Function Designator (FD) — Data processed by the CLCS which has been acquired from the End Item under test, calculated by Data Fusion, determined by System Software, derived by a user test application or the last commanded value of an output command. Measurement FDs consist of the following specific FDs:

1. End Item FDs
2. Data Fusion FDs
3. System Status FDs
4. Pseudo FDs
5. Commanded Status FDs

Multi-Function Room (MFR) — The Multi-Function Room is one of the rooms which was formerly a KSC Launch Control Center (LCC) Firing Room. The MFR contains the Flow Zone and Shared I/O Area used for Flight Vehicle, Payload and GSE Processing.

Non-Controlling — A term used to describe a software process that is designated to replace the Controlling process in the event of a failure. The Non-Controlling process monitors the system configuration but does not actively manage the configuration unless the Controlling process fails.

Non-Intrusive — Any process or event which will not significantly alter the normal configuration or operation of a operational, on-line CCMS or RTPS resource.

Non-Operational — The state of a CCMS or RTPS resource known to not be ready to support an activity.

Off-line — A term used to signify a physical CCMS or RTPS resource is neither ready to participate nor is participating within a CCMS or RTPS Set.

On-line — A term used to signify a physical CCMS or RTPS resource is ready to participate or is actively participating within a CCMS or RTPS Set.

Operational — The state of a configured, initialized CCMS or RTPS resource that is ready to support.

Operational Readiness Test (ORT) — A set of software used to verify that a subsystem's hardware and software is ready to support testing.

Operations Control Room (OCR) — Operations Control Rooms are rooms which were formerly KSC Launch Control Center (LCC) Firing Rooms. The OCR contains the Flow Zone and Shared I/O Area used for Flight Vehicle, Payload and GSE processing.

Override — An override is a keyboard command to Prerequisite Control Logic (PCL) requiring PCL to issue a command that has failed its prerequisite checks.

Platform Load — The combination of the tailored Operating System (OS) and COTS software which may be loaded onto a CLCS Subsystem HW.

Prerequisite Sequence — A prerequisite sequence may be defined for every end item command. When a command with a prerequisite sequence is issued from the keyboard or an application program the prerequisite sequence is executed. If the prerequisites are passed, the command is issued; otherwise, it is rejected.

Processed Counts — Processed counts are raw counts that have undergone subtype-dependent processing in the FEP (i.e., converted counts). Processed counts have been linearized by the FEP using line segment data from its' tables, if the measurement requires it, and are bipolar, 2's complement, big-endian integer values. The LPS "definition" of this term is vague and imprecise, at times meaning right justified counts, and at other times meaning left-justified counts (see CDBFR counts).

Pseudo Function Designator — A pseudo FD is a FD that is updated by applications within the RTPS. Pseudo FDs have many of the characteristics of measurement FDs (e.g., they are defined in the CLCS Data Bank, have On-line Data Bank entries, may be used by Data Fusion, etc.).

Raw Counts — Raw counts are the count values as received from the hardware. These counts are right justified. Raw counts are represented by an Integer value whose range depends on the measurement length. The normal count range for an 8-bit unipolar GSE measurement is +3 to +253. A 10 bit PCM bipolar measurement ranges from -512 to +511.

Real-Time Processing System (RTPS) — The Real-Time Processing System consists of Gateway Groups, Control Groups and Flow Zones. This equipment performs the real-time processing for CLCS.

Reduced Capability Mode — A mode of the CLCS in which all normal functionality defined for the Test Set is not present. This mode may be entered in a number of ways.

Redundant Pair — A term used to represent the association of an Active/Standby resource.

Register — This term is used to indicate that a program can request notification when an event takes place in much the same way that people register to vote or to be notified when a new version of software is available. Examples of the kinds of events programs can register for are constraint violation, constraint satisfaction, time of day.

Registered User — Registered User is a generic term used to indicate that a system or user application has requested notification when an event takes place.

Responsible System — The system responsible for monitoring a given set of hardware and/or software end items.

RTPS Set — The collection of equipment in a physical facility that is interconnected and dedicated to performing a major function or task (e.g., CITE is used for Payload Integration and Checkout). The equipment contained in a RTPS Set consists of the equipment contained in Flow Zones, Control Groups, Gateway Groups, and associated Networks (RTCN, DCN, & RON). Table A-1 lists the CCMS and RTPS Sets.

| Set Name | CCMS Set | RTPS Set |
|---|---|---|
| Launch Control Center (LCC) Set | N | Y |
| Cargo Integrated Test Equipment (CITE) Set | Y | Y |
| Complex Control (CCS) Set | Y | TBD |
| Firing Room Number 1 | Y | N |
| Firing Room Number 2 (Multiple Sets) | Y | N |
| Firing Room Number 3 | Y | N |
| Hypergol Maintenance Facility (HMF) Set | Y | Y |
| Dryden Flight Research Center (DFRC) Set | Y | Y |
| Kennedy Avionics Test System (KATS) Set | N | TBD |
| Processing Control Center | Y | N |
| Shuttle Avionics Integration Lab (SAIL) Set | Y | Y |
| Development Sets<br>Integrated Development Environment (IDE) Set<br>Satellite Development Environment (SDE) Set | <br>N<br>N | <br>Y<br>Y |

**Table A-1 - CCMS and RTPS Sets**

Safing Subsystem — A collection of hardware that provides a means independent from RTPS computational equipment to place a facility or Flight Vehicle into a known and safe state.

Satellite Development Environment (SDE) Set — There are two types of Satellite Development Environment Sets.

1. The System Software SDEs (2 ea.) will be located close to the System Software developers, initially in the Engineering Development Laboratory (EDL) then in the Processing Control Center (PCC). The SDEs are used to develop, unit test, and integrate CLCS System Software prior to integration at the IDE.
2. The Application Software SDE is located in the PCC building at the Kennedy Space Center. This set is used to develop, unit test, and integrate CLCS Application Software prior to integration at the IDE.

Shareable Library — A collection of object code which may be linked with other object code at run time

Shared I/O Area — The area in an Operations Control Room (OCR), Multi-Function Room (MFR), or Specialized Processing Site containing printers, plotters, and other devices that are shared by multiple users in the Test Set.

Set Point — The value of a function in a closed loop application that the End Item Manager is maintaining.

Shuttle Avionics Integration Lab (SAIL) Set — The Shuttle Avionics Integration Lab Set is located at the Johnson Space Center. The SAIL Set is used to verify CLCS Software in the avionics integration environment at SAIL.

Shuttle Data Center (SDC) — **Placeholder**

Shuttle Data Stream (SDS) — The Shuttle Data Stream is the stream of data provided by a KSC CCMS Set to users of the data not in that Set.

Simulation System — **Placeholder**

Software Release — A collection of files, together with their version number, that make up a software build.

Specialized Processing Site — **TBD**

Standby — A term used to identify which one of the computers in an Active/Standby pair is designated to replace the Active in the event of a failure. The Standby subsystem is maintained in a “hot” standby state (i.e., it can immediately assume the role of the failed Active).

Station Set — A Station Set is a facility and all of its equipment (e.g., OV 104, Pad A, High Bay 1, OPF 1).

Subsystem — The collection of hardware and software that is combined to perform a specific set of functions.

Subsystem Hardware — The Hardware Configuration Items (HWCI) that are required to perform the functions of a subsystem.

Subsystem Load — The Computer Software Configuration Items (CSCI) that are combined to perform the functions of a subsystem.

Synchronized Load Files — Load files that result when multiple subsystem load files are created using the same versions of object code by System Build Software.

System Application — Software that is developed by the System Software Development group in the CLCS project. This software is midway between system software and pure application software. It performs operations that relate to end items and is created by this group in order to provide a consistent set of services to all users of the CLCS.

System Configuration Identifier (SCID) — System Configuration Identifier is a CLCS term used in two different instances:

1. The label used to identify the System Build products constructed for a CLCS release
2. The collection of System Build products used in the RTPS subsystem computers.

System Services — **Placeholder**

System Software Build — The process of creating software that is ready for loading into the RTPS subsystem computing equipment.

System Synchronous Rate (SSR) — **Placeholder [Issue, need requirement]**

System Thread — The set of software in a CLCS delivery that provides a system-wide capability.

Test Article — Test Article is a little used term to specifically define a system and may be composed of multiple End Items (e.g., the APU System is a Test Article).

Test Build — The process of creating the test environment specific data, tables, etc., and preparing this information for loading into a TRE.

Test Configuration Identifier (TCID) — Test Configuration Identifier is a CLCS term used in two different instances:

1. The label used to identify the Test Build products constructed for a CLCS release
2. The collection of Test Build products that define the set of end items to be tested.

Test Package — **TBD** (Rex S.)

Test Set — A group of CLCS RTPS Subsystems and networks configured for a specific test. Typically a Test Set will include one or more Gateways within a Gateway Group, some portion of an RTCN’s bandwidth, one or more DDPs and CCPs within one or more Control Groups, some portion of a DCN’s bandwidth, and one or more Console Positions. This entire set of equipment would constitute a Test Set. For example, a Launch configured Test Set would include all the Gateways in that Pad’s Gateway Group, RTCN, two Control Groups with several

DDPs and a larger number of CCPs utilized, the DCN within that OCR, and a Flow Zone consisting of all the Console Equipment in that OCR.

Thread — See System Thread.

Time Homogeneous Data Set (THDS) — A group of measurement data or measurements which must be viewed when the data is quiescent and not during the time it is changing.

User — The term user is used in this document to mean a human being that is using CLCS equipment (hardware and software) to perform a given task. There are many users of the CLCS system

1. Operations user — one who uses the CLCS to process and or control end items.
2. Build user — one who uses the CLCS to build, system or test, software products to be used in the CLCS.
3. O&M user — one who operates and maintains the CLCS equipment.

User Application — This term is used in this document to refer to a software application that is written to deal exclusively with end items. It is written by the User Application Software group within the CLCS project.

Vehicle Processing (VP) Set — The Vehicle Processing Set consists of all of the CLCS equipment in the OCRs and MFR of the LCC at the Kennedy Space Center. This equipment is considered to be one set because subsets of the equipment may be configured into many different TREs and connected to different station sets at any given time.

Workstation — A desktop computer. In a CLCS OCR a workstation is a desktop computer utilized in a CLCS Console Position or Console Support Module. There are two kinds of workstations in CLCS:

1. Workstations for executing CLCS applications and viewing CLCS displays. This workstation could have more than one monitor.
2. Workstations for business systems connectivity to access on-line documentation and historical log books, generate deviation paperwork (e.g., IPRs, PRACA, Deviation Records) and to provide connectivity to center-wide and world-wide information.

# Appendix B. — DATA TYPES

This section contains a definition of LPS Data Types and Subtypes. It also contains a matrix describing the LPS links and the allowable types and subtypes on each link.

## TYPES

The assignment of TYPE to an FD indicates to CLCS the basic data configuration and type of processing to be performed. Descriptions of the various Types are as follows:

### Analog Measurement (AM)

- Represents an analog signal input to CLCS
- May be unipolar or bipolar
- 1 to 16 bits in length

### Analog Measurement Serial Input/Output (AMS)

- Represents an analog signal input to CLCS from an onboard serial input device
- May be unipolar or bipolar
- 2 to 16 bits in length
- Accessible via the Launch Data Bus (LDB)

### Analog Stimulus (AS)

- Represents an analog signal output from CLCS
- May be unipolar or bipolar
- 2 to 16 bits in length

### Analog Stimulus Serial I/O (ASS)

- Represents an analog signal output from CLCS to an onboard serial output device
- May be unipolar or bipolar
- 2 to 16 bits in length
- Accessible via the LDB

### Discrete Measurement (DM)

- Represents a discrete event input to CLCS
- 1 bit in length

### Discrete Measurement Serial I/O (DMS)

- Represents a discrete event input to CLCS from an onboard serial input device
- 1 bit in length
- Accessible via the LDB

### Digital Pattern Measurement (DPM)

- Represents a numeric quantity input to CLCS
- 2 to 16 bits in length

### Digital Pattern Measurement Serial I/O (DPMS)

- Represents a numeric quantity input to CLCS from an onboard serial input device
- 2 to 16 bits in length
- Accessible via the LDB

### Digital Pattern Stimulus (DPS)

- Represents a numeric quantity output from CLCS

- 2 to 16 bits in length

### Digital Pattern Stimulus Serial I/O (DPSS)

- Represents a numeric quantity input from CLCS to an onboard serial output device
- 2 to 16 bits in length
- accessible via the LDB

### Digital Pattern Stimulus With Data (DPSD)

- Represents a digital pattern stimulus with a fixed data pattern to be sent from CLCS to an onboard device - may be one or two words of data, depending on BTU class
- Accessible via the LDB and Uplink

### Double Precision Analog (AMDP)

- Represents an analog signal input to CLCS
- 17 to 32 bits in length

### Discrete Stimulus (DS)

- Represents a discrete output from CLCS - 1 bit in length

### Discrete Stimulus Serial I/O (DSS)

- Represents a discrete event output from CLCS to an onboard serial output device
- 1 bit in length
- Accessible via the LDB

### Floating Point (FP)

- Represents an analog signal input to CLCS
- May be either half, single, extended, or double precision with corresponding lengths of 16, 32, 48, and 64 bits
- Accessible via EIU1, EIU2, EIU3, GPCLNK and LDB (GMM)

### Multiword Digital Pattern (MWDP)

- Represents a numeric quantity
- 17 to 64 bits in length
- Accessible via EIU1, EIU2, EIU3, and GPCLNK
- Generated at KSC (not in JSC MMDB)

## SUBTYPES

The assignment of SUBTYPE to a FD provides additional details of the data configuration for analog measurements and stimuli, floating point measurements and digital pattern stimuli with data.  For digital pattern types, subtype information allows the assignment of the numerical base for displaying and recording the Function Designator.  Description of the various subtypes are as follows:

### Analog Measurement and Stimuli Subtypes

### Analog Bipolar (AB)

- The left most bit is the sign bit
- The next bit is the MSB
- The right bit is the LSB
- The magnitude bits describe a decimal integer in binary
- If the sign bit is negative (1) then the magnitude is in two’s compliment form

### Analog Unipolar (AU)

- For KSC GSE the left most bit is the MSB

- For LDB and PCM the second bit is the MSB
- The magnitude bits describe a decimal integer in binary

### Binary Coded Decimal (BCD)

- The start bit is the MSB
- The magnitude bits are a four bit BCD code describing a decimal number starting with the LSB

### Bit String Magnitude (ASM)

- The left most bit is the sign bit
- The second bit is the MSB
- The magnitude bits describe a decimal number in binary

### Halfword Overflow Signed (AOS)

- The left most bit is the sign bit
- The second bit is the overflow bit

  1 = overflow 0 = No overflow
- The third bit is the MSB
- The magnitude bits describe a decimal number in binary

### Halfword Unsigned (AHU)

- The left most bit is the MSB
- The magnitude bits describe a decimal number in binary

### TACAN Bearing Word (TAB)

- MMDB BSE data type
- 2-15 bits in length
- Has a data range and units
- Originates from TAC card
- Card and channel location is zero
- The start bit is the MSB

### Analog Measurement Filter (AMF)

- Has a length of 1
- The Gateway will compute a 16 bit bipolar analog filtered value for ET OI point sensors
- Valid on all PCM links
- Has an associated AMF constant whose value is less than 1 and greater than zero; up to 6 digits to the right of the decimal point may be specified
- Significant change parameter is invalid for this subtype

## <u>Floating Point Subtypes</u>

Only valid on the GPCLNK

### Half Precision (HPL)

- Length is 16 bits
- In CCMS this subtype was treated by GOAL and the CCMS Command Processor as an SPL subtype

### Single Precision (SPL)

- Length is 32 bits
- A floating point number consisting of an unsigned characteristic (or exponent) and a signed fraction; the quantity expressed by this number is the product of the fraction and the number 16 raised to the power of the exponent

where:

Bit 00 = Sign of Fraction
= Positive
= Negative

Bit 01-07 = Characteristic - A binary number with a range of 0 through 127. The exponent is derived by subtracting 64 from the characteristic. Therefore, the range of the exponent is -64 through +63.

Bit 08-31 = Fraction - A binary number less than 1 with the binary point to the left of the high order digit (between bit 7 and 8)

### Extended Precision (EPL)

- Length is 48 bits
- In CCMS this subtype was treated by GOAL and the CCMS Command Processor as a DPL subtype

### Double Precision (DPL)

- Length is 64 bits
- A floating point number consisting of an unsigned characteristic (or exponent) and a signed fraction; the quantity expressed by this number is the product of the fraction and the number 16 raised to the power of the component

Bit 00 = Sign of Fraction
0 = Positive
1 = Negative

Bit 01-07 = Characteristic - A binary number with a range of 0 through 127. The exponent is derived by subtracting 64 from the characteristic. Therefore, the range of the exponent is -64 through +63.

Bit 08-63 = Fraction - A binary number less than 1 with the binary point to the left of the high order digit (between bits 7 and 8)

## Double Precision Analog Subtypes (Downlist Only)

### Analog Bipolar (AB)

- The left most bit is the sign bit
- The second bit is the MSB
- The magnitude bits describe a decimal integer in binary

### Analog Unipolar (AU)

- the left most bit is the MSB
- the magnitude bits describe a decimal integer in binary

### TACAN Range Word (TAC)

- The length must be 18 bits
- The start bit is the MSB
- The magnitude bits are assumed to be a four bit code defining a decimal number starting with the LSB

## Digital Pattern Subtypes

Digital pattern subtypes provide a means of specifying the numerical base for displaying and recording the FD values for digital patterns of 2-16 bits. Valid subtypes are as follows:

OCT - Octal Number

HEX - Hexadecimal Number
BCD - Binary Coded Decimal Number
BIN - Binary Number
DEC - Decimal Number

## Discrete Subtypes

Valid Subtypes are as follows:

BD - Binary Discrete

## Multiword Digital Pattern Subtypes

The Multiword digital pattern subtypes provide a means of specifying the numerical base for displaying and recording measurement values with data lengths between 17 and 64 bits. Valid subtypes are as follows:

BIN - Binary Number
OCT - Octal Number
DEC - Decimal Number
HEX - Hexadecimal

## Digital Pattern Stimuli With Data (DPSD) Subtypes

The DPSD subtypes provide a means of specifying exact bit configurations for digital pattern commands. The valid subtypes for DPSD commands are ONE and TWO.

### ONE

- only one 16 bit data word is required
- the bit configuration will be available in the WRD1 field of the CLCS Databank as an unsigned decimal integer

### TWO

- two 16 bit data words are required
- the bit configurations will be available in the WRD1 and WRD2 fields of the CLCS Databank as unsigned decimal integers
- WRD1 and WRD2 apply to two hardware addresses for FD's with a BTU class of MDM or FLX

## Bus Terminal Unit (BTU) Subtypes

The BTU subtypes provide a means of identifying specific PDI/PCR functions.

Valid subtype assignments for BTUC=PDI:

FPM - Fetch Pointer Memory
DC1 - Decom 1
DC2 - Decom 2
DC3 - Decom 3
DC4 - Decom 4
DRM - Data RAM
BSR - BITE Status Register
SMR - Switch Matrix

Valid subtype assignments for BTUC=PCM

PCM - Unassigned PCM
POI - PCMMU OI
P28 - PCMMU 128
P64 - PCMMU 64

NOTE: The subtype parameter is only valid for BTU with a BTU class of PDI or PCM.

## VALID TYPES AND SUBTYPES FOR LINK AND TYPE

| GATEWAY LINK / TYPE | CITE GSE LINKS | LDB | UPLINK | PLDOI PLDPL EIU1-3 COMMON DOWNLINKS ET OILNK | FAC1 | TMDB | SDBLK1-2 |
|---|---|---|---|---|---|---|---|
| AM | AU | AU, AB, AHU, ASM, AOS, TAB, BCD | | AMD, AMF, AU, AB, AHU, ASM, AOS, TAB, BCD | AB | | AB, AU |
| AMDP | | | | AU, AB, TAC** | | | |
| AMS, ASS | | AU, AB, AHU, ASM, AOS, TAB, BCD | | | | | |
| AS | AU | AU, AB, AHU, ASM, AOS, TAB, BCD | | | | | |
| BTU | | BSR, FPM, DC1, DC2, DC3, DC4, DRM, PCM, POI, P28, P64, SMR | BSR, FPM, DC1, DC2, DC3, DC4, DRM, PCM, POI, P28, P64, SMR | | | | |
| DM | BD | BD | | BD | BD | BD | BD |
| DMS, DSS | | BD | | | | | |
| DPM | DEC, OCT, HEX, BIN, BCD | DEC, OCT, HEX, BIN, BCD | | DEC, OCT, HEX, BIN, BCD | | | |
| DPMS, DPSS | | DEC, OCT, HEX, BIN, BCD | | | | | |
| DPS | DEC, OCT, HEX, BIN, BCD | DEC, OCT, HEX, BIN, BCD | DEC, OCT, HEX, BIN, BCD | | | | |
| DPSD | | ONE, TWO | ONE, TWO | | | | |
| DS | BD | BD | BD | | BD | BD | BD |
| FP | | *** SPL, DPL | | **** SPL, DPL, HPL, EPL | | | |
| MWDP | | | | BIN, OCT, DEC, HEX | | | |

** Subtype of TAC not valid on 8-bit PCM links

*** Floating Point on LDB must have a BTU class of GMM

**** Floating Point not valid on the following 8-bit PCM Links: OILNK, ET, COMMON DOWNLINKS, PLDOI, PLDPL

# Appendix C. — CCMS KEYBOARD

## Command Portability Matrix

The table on the following pages list CCMS commands, OC tasks, Transients, and Programs. These commands and programs were compiled by searching the CCMS Design Documents and User's Guides for each. Following is a description of each column in the tables:

- COMMAND DESCRIPTION - A description of the command and the proposed syntax.
- PORT - N/Y = Whether existing command should be recoded.
  - E = Equivalent functionality required
  - D = Duplicate functionality provided elsewhere
- CP - Rewrite as a Command Processor command
- SV - Rewrite as a System Viewer command
- SA - Rewrite as a System-Written Application command
- UA - Rewrite as a User-Written Application command

KEYBOARD COMMAND PORTABILITY MATRIX

| COMMAND DESCRIPTION | PORT | CP | SV | SA | UA |
|---|---|---|---|---|---|
| CCMS Installation ($INST) | E | | | Y | |
| Load Operations (MCPRELD) | E | | | Y | |
| Test Operations Change ($TOC) | N | | | | |
| CCMS Load and Initialization ($CLAI) | E | | | Y | |
| CCMS Configuration Update (UPDATE) | E | | | Y | |
| CCMS Termination ($TERM) | E | | | Y | |
| Checkpoint Restart (GWCPR) | Y | | | Y | |
| Checkpoint Restart (User Application Interface) | N | | | | |
| Application Procedure Control | Y | Y | | | |
| PCM Source Select (PCMS) | Y | Y | | | |
| Display Monitor (DMON) | Y | Y | Y | | |
| Exception Monitor (A/I SX) | Y | Y | Y | | |
| Status Hot Spares (S HS) | E | Y | Y | | |
| Read GSE HIM Output Function Designator (R FD) | New | Y | Y | | |
| Status Function Designator (S FD) | Y | Y | Y | | |
| Status Inhibited FDs (SIFD) (GOAL can call SIFD) | Y | | Y | Y | |
| Switch Scan (SWSCAN) | Y | | | Y | |
| System Status (SYST) | Y | | Y | Y | |
| Act/Inh Data Acquisition (A/I DA) | Y | Y | | | |
| Act/Inh Data Processing (A/I PR) | Y | Y | | | |
| Act/Inh Command Issuance (A/I CM) | Y | Y | | | |
| Allow/Inh LDB/UPLK Requests (A/I CMD) | Y | Y | | | |
| Act/Inh SPA to issue LDB commands (A/I SP) | E | Y | | | |
| Act/Inh GOAL Exception Notification (A/I GX) | E | Y | | | |
| Act/Inh Control Logic Exception Notification (A/I CX) | E | Y | | | |
| Act/Inh CDS Logging (A/I CD) | N | | | | |
| Act/Inh Linearization (A/I LI) | Y | Y | | | |
| Act/Inh HIM Polling Command (A/I HI) | Y | Y | | | |
| Act/Inh HIM Testing Command (A/I HT) | Y | Y | | | |
| Act/Inh SMW Routing (A/I SM) | N | | | | |
| Allow/Inhibit Redundant Switch (A/I RS) | Y | Y | | | |
| Act/Inh Inhibit Serial Dump Processing (A/I SD) | Y | Y | | | |
| Act/Inh EMON Alarm Notification (A/I EN) | Y | Y | | | |
| Act/Inh Polling On An RTU (A/I RT) | Y | Y | | | |
| Allow/Inh Keybd Perform Of Utilities (A/I KU) | Y | Y | | | |

| COMMAND DESCRIPTION | PORT | CP | SV | SA | UA |
|---|---|---|---|---|---|
| Allow/Inh Remote S/W Perform Of Utils (A/I RU) | Y | Y | | | |
| Act/Inh ESA Use of SPA Utilities (A/I ES) | N | | | | |
| Act/Inh Commit Criteria Notification (A/I CC) | Y | Y | | | |
| **Act/Inh Fuel Cell Simulation (A/I FS)** | Y | | | | |
| **Act/Inh Preview Command (A/I PV)** | Y | Y | | | |
| Act/Inh System Test (A/I ST) | Y | Y | | | |
| Act/Inh Operational Mode (A/I OP) | Y | Y | | | |
| Act/Inh PCM Sync Message Routing (A/I SR) | Y | Y | | | |
| Act/Inh All Alarms (A/I AA) | Y | Y | | | |
| Act/Inh Single Alarm (A/I AL) | Y | Y | | | |
| Act/Inh Fire Alarm Notification (A/I FN) | N | | | | |
| Change GOAL Limits (C GL) | E | Y | | | |
| Change CL Limits (C CL) | E | Y | | | |
| Change EM Limits (C EL) | E | Y | | | |
| Change Responsible Console (C CO) | Y | Y | | | |
| Change RCU Number (C RC) | E | Y | | | |
| Change Hardware Address (C HA) | Y | Y | | | |
| Change Linearization Curve Pointer (C LI) | Y | Y | | | |
| Change Sample Rate (C RA) | Y | Y | | | |
| Change Significant Change Value (C SI) | Y | Y | | | |
| Change PCM Bit Sync Bit Error Count (C PS) | Y | Y | | | |
| Change PCM Source Select (PCMS) | Y | Y | | | |
| Change Physical Port (C PP) | E | Y | | | |
| Change In Configuration Indicator (C IC) | E | Y | | | |
| Change Digital Filter Constant (C FC) | Y | Y | | | |
| Change Reference Designator (REFD) | E | Y | | | |
| Change Commit Criteria Console (C CC) | Y | Y | | | |
| Change Fuel Cell Aging Constant (C FS) | Y | Y | | | |
| Change DECOM to Area Assign. (C DC) | Y | Y | | | |
| Change Station Id/Chg Block Seq No. Chk Mode (C SN) | Y | Y | | | |
| **Change Forward Link (C FL)** | Y | Y | | | |
| **Change Payload Coeff. Scaling Set (UPSC)** | Y | | | | |
| Apply Analog (APPL) | Y | Y | | | |
| Set Discrete (SET) | Y | Y | | | |
| Issue Digital Pattern (ISSU) | Y | Y | | | |
| Stop Repeated MDM Single (STRP) | Y | Y | | | |
| Preformatted 48 Bit (P48B) | Y | Y | | | |
| Restart React. Sequence At Beginning (RSRS) | E | Y | | | |
| Retry Failed Reactive Sequence (RTRS) | E | Y | | | |
| Continue Failed Reactive Sequence (CORS) | E | Y | | | |
| Switch LDB (SW L) | Y | Y | | | |
| Resume LDB Command (RLDB) | Y | Y | | | |
| Present Value Of FD (PVO) | Y | Y | | | |
| GMEM Read (GPCC LDBA, or GPCC LDBD) | Y | | | | Y |
| GMEM Write (GPCC LDBA, GPCC LDBD, or GPCC UPLK) | Y | | | | Y |
| LDB Control (GPCC LDBC) | Y | | | | Y |
| Explicitly Coded Program (GPCC DDC, RFG, FRT, MAT, BFD, BFM, ACTI) | Y | | | | Y |
| Dump/Load Onboard Regs. (GPCC DPREG, LDREG) | Y | | | | Y |

| COMMAND DESCRIPTION | PORT | CP | SV | SA | UA |
|---|---|---|---|---|---|
| SSME Read (GPCC SSME) | Y | | | | Y |
| SSME Write (GPCC SSME) | Y | | | | Y |
| TCS Sequence Initiate (TCSS) | Y | | | Y | |
| TCS Text Operator (TEXT O/G) | Y | Y | | | |
| TCS Stop Operator (STOP <TCS-S) | Y | Y | | | |
| TCS Cancel Operator (CANCEL) | Y | Y | | | |
| TCS Resume Operator (RESUME) | Y | Y | | | |
| Display Electronic Unit (DEUE) Equivalent | Y | Y | | | |
| Command BTU Tests (CBTU) | Y | Y | | | |
| Set Uplink Activity Indicator (UACT) | Y | Y | | | |
| Word-By-Word Correction (WBWC) | Y | Y | | | |
| Read Onboard Values (READ) | Y | | | | Y |
| Command Payload (CPLD) | Y | Y | | | |
| Read MEC (RMEC) | Y | Y | | | |
| Command MEC (CMEC) | Y | Y | | | |
| Two-Stage Buffer Control (TSBF) | Y | Y | | | |
| Video Switch Control (VSWI) | Y | Y | | | |
| Timing and Distribution PBIC Control (TMDS) | N | | | | |
| Buffer Scan Diagnostic PBIC Control (BSD) | N | | | | |
| PBIC RAM Read (RAMR) | N | | | | |
| Initialize Timer (TCGI) | TBD | | | | |
| Initialize Timer (MTUI) | TBD | | | | |
| CDT Count At GMT (CDTC) | Y | | | | |
| MET Count At GMT (METC) | Y | | | | |
| CDT Hold At CDT (CDTH) | Y | | | | |
| MET Hold At CDT (METH) | Y | | | | |
| CDT Hold (CDTH) | Y | | | | |
| MET Hold (METH) | Y | | | | |
| CDT Count (CDTC) | Y | | | | |
| MET Count (METC) | Y | | | | |
| Set CDT Time (CDTS) | Y | | | | |
| Set MET Time (METS) | Y | | | | |
| Reset Pending Commands To Hold Or Count (CDTR) | Y | | | | |
| Reset Pending Commands To Hold Or Count (METR) | Y | | | | |
| Switch Timing To External (TCGE) | TBD | | | | |
| Switch Timing To External (MTUE) | TBD | | | | |
| Switch Active Time Source (TCGS) | TBD | | | | |
| Terminate Timer (TCGT) | TBD | | | | |
| Terminate Timer (MTUT) | TBD | | | | |
| Allow CDT Control (TCGA) | Y | | | | |
| Allow MET Control (MTUA) | Y | | | | |
| Restrict CDT Control (TCGR) | Y | | | | |
| Restrict MET Control (MTUR) | Y | | | | |
| GMT Sync (GMTS) | TBD | | | | |
| Add Linearization Curve (ADDL) | Y | | | Y | |
| SPC Buffer Clear (CSPC) | Y | Y | | | |
| LDB SRB MDM Lock/Unlock (LOCK/UNLOCK) | Y | Y | | | |
| Orbital Computational Facility (OCFI)<br>OCFI (Cont.)<br>(Shuttle Memory Load and Dump)<br>T-20 Minute Compare | Y | | | Y | |

| COMMAND DESCRIPTION | PORT | CP | SV | SA | UA |
|---|---|---|---|---|---|
| GPC Dump<br>GPC Compare<br>DEU Dump<br>DEU Compare<br>Tape Dump Other Than UPF Format<br>Tape Dump UPF Format<br>List RPL MMU 1<br>List RPL MMU 2<br>Patch MMU 1<br>Patch MMU 2<br>Load MMU 1 Without Verification<br>Load MMU 2 Without Verification<br>Dump MMU 1<br>Compare MMU 1<br>Dump MMU 2<br>Compare MMU 2<br>Dump PCM Telemetry Format 64<br>Compare PCM Telemetry Format 64<br>Dump PCM Telemetry Format 128<br>Compare PCM Telemetry Format 128<br>Dump PCMOI<br>Patch Main Memory via LDB<br>Dump BFS Tape<br>Compare BFS Tape<br>Dump GPC Tape<br>Compare GPC Tape<br>Dump MMU Tape<br>Compare MMU Tape<br>Patch Main Memory via UPLK<br>Load MMU 1 With Write Verification<br>Load MMU 2 With Write Verification<br>Block II FDR Dump of EIU x EC x<br>Dump DEU Tape<br>Compare DEU Tape<br>Dump Block II EIU Tape<br>Compare Block II EIU Tape<br>Block II Dump of EIU x EC x<br>Block II Dump of EIU x EC x<br>Block II SSME Load EIU x EC x | | | | | |
| **T-20 Minute Patch (PT20)** | Y | | | TBD | TBD |
| Plotting Measurement Data (PP) | Y | | | Y | |
| Hardware Monitor (HWMON) | Y | | Y | Y | |
| **Avionics Diagnostics (AVDIAG)** | TBD | | | | |
| **Change SCA Bus Assignment (C BA)** | TBD | | | | |
| **Change Spacelab Coupler (C SL)** | TBD | | | | |
| Dump Cpu Memory ($DUMPMEM) | Y | | | Y | |
| Display Cpu Memory ($DPLYMEM) | Y | | | Y | |
| Alter Cpu Memory ($ALTRMEM) | Y | | | Y | |
| Dump Disk ($DUMPDSK) | Y | | | Y | |
| Display Disk ($DPLYDSK) | Y | | | Y | |
| Alter Disk ($ALTRDSK) | Y | | | Y | |
| Dump CDBFR ($DUMPCDB) | N | | | | |
| Display CDBFR ($DPLYCDB) | N | | | | |
| Alter CDBFR ($ALTRCDB) | N | | | | |
| Dump Bulk Memory ($DUMPBLK) | N | | | | |

| COMMAND DESCRIPTION | PORT | CP | SV | SA | UA |
|---|---|---|---|---|---|
| Display Bulk Memory ($DPLYBLK) | N | | | | |
| Alter Bulk Memory ($ALTRBLK) | N | | | | |
| Dump Gateway Memory ($DUMPGW) | Y | | | Y | |
| Display Gateway Memory ($DPLYGW) | Y | | | Y | |
| Alter Gateway Memory ($ALTRGW) | Y | | | Y | |
| Dump Halted Gateway Memory ($UTFEPD) | N | | | | |
| Display Skeleton ($DPLYSKE) | N | | | | |
| Print Load Map ($MAP) | Y | | | Y | |
| Disk Initialization ($MHDCLR) | N | | | | |
| Copy/Verify Operating System ($COPY) | E | | | | |
| Zero CDBFR ($ZCDB) | E | | | Y | |
| Rebuild Control Logic Sequence ($CSRBCL) | N | | | | |
| Load File Patcher ($PATCHER) | Y | Y | | | |
| **Application Debug Software ($ADS)** | TBD | | | | |
| Application Library List Programs ($PRTLIB) | E | | | Y | |
| Build Tailored Buffer Map ($BMAP) | E | | | Y | |
| Compute ($COMPUTE) | Y | | | Y | |
| Library ($LIBRARY) | Y | | | Y | |
| Remote CPU Memory Dump ($BTDUMP) | E | | | Y | |
| Convert GMT to Hex ($GMTHEX) | Y | | | Y | |
| Command File Processor ($CMD) | Y | | | Y | |
| Dump Library Entry ($DUMP) | N | | | | |
| Recall Prompts ($RECALL) | N | | | | |
| Global Buffer Map Status Report ($GBSR) | E | | | Y | |
| Print One File ($PRINT) | N | | | | |
| List Task Control Block Activity ($LIST) | E | | | Y | |
| Convert Hex to GMT ($HEXGMT) | Y | | | Y | |
| Delete Library Entry ($DELENT) | E | | | Y | |
| Return Library Information ($INFO) | N | | | | |
| Create Disk Library ($BLDLIB) | N | | | | |
| Dump Bulk Disk ($DUMPBD) | N | | | | |
| Dump Bulk Tape ($DUMPBKT) | E | | | Y | |
| Level G Stop Routine ($GSTOP) | N | | | | |
| Monitor Gateway Memory ($MONGW) | Y | | | Y | |
| Search CDBFR ($SRCHCDB) | N | | | | |
| Search Gateway Memory ($SRCHGW) | Y | | | Y | |
| Search CPU Memory ($SRCHMEM) | Y | | | Y | |
| Monitor CPU Memory ($MONMEM) | Y | | | Y | |
| Monitor CDBFR ($MONCDB) | N | | | | |
| Patch Data Sets ($PATCH) | E | | | Y | |
| Merge Library Entry ($MRGENT) | E | | | Y | |
| **POCC Command Preview ($PREVU)** | Y | | Y | Y | |
| Time Status ($TIME) | N | | | | |
| Message Broadcast ($MSGB) | N | | | | |
| Display/Alter On-Line Data Bank ($OLDB) | Y | | | Y | |
| Display DG Page/PFP Presentation ($DGPG) | N | | | | |
| GOAL Procedure Status ($GOAL) | E | | | Y | |
| Bulk Disk Clear/Copy/Verify ($BULK) | N | | | | |
| Print Bad Sector table ($PBST) | N | | | | |
| **Copy GOAL Disk File (CGDF)** | TBD | | | | |
| TCID Information Formatted (TCID) | Y | | | Y | |
| GOAL IC Operator Dump ($GLDUMP) | E | | | Y | |
| GOAL IC Operator Dump At SPA ($GLSPA) | N | | | | |

| COMMAND DESCRIPTION | PORT | CP | SV | SA | UA |
|---|---|---|---|---|---|
| Arithmetic Expression Evaluator ($CALC) | N | | | | |
| Transient Memory Dump Formatter ($STTWA) | N | | | | |
| Text Editor ($T) | Y | | | Y | |
| **Date ($DATE)** | Y | | | Y | |
| Execute Command File ($CMD) | N | | | | |
| Firing Room Configuration Verify ($VERIFY) | N | | | | |
| Snap Registers ($SNAP) | N | | | | |
| Status On-Line Data Bank ($STOLDB) | Y | | | | |
| Dump TR Library Entry ($TRDUMP) | N | | | | |
| Skeleton Build ($SKLBLD) | N | | | | |
| Monitor Locations in Memory ($MON) | Y | | | Y | |
| Alter Memory In OC Task ($ALTROC) | N | | | | |
| **Avionics Diagnostics Loader (AVLOAD)** | TBD | | | | |
| Bulk Disk Installation ($BDINST) | N | | | | |
| Bulk Disk Preload ($BDPRELD) | N | | | | |
| Build Control Logic File ($BLDCL) | N | | | | |
| LDB BTU FD Status ($BTU) | N | | | | |
| Change IC And Physical Port And RCU ($C) | N | | | | |
| Computer Assisted Instruction ($CAI) | N | | | | |
| Write Meas. Values & FEP Exceptions ($CDBFRW) | Y | | | Y | |
| Command File Executor - OC Task ($CMDOC) | N | | | | |
| Buffer Stress Test Monitor ($CSD) | E | | | Y | |
| Configuration Update Allow/Inhibit ($CSUBUP) | N | | | | |
| DIT Control Program ($DITCP) | N | | | | |
| DIT Monitor ($DITMON) | N | | | | |
| ORT 50KB Test Item 1 ($DP150K) | E | | | Y | |
| ORT Bulk Memory Test Item 1 ($DP1BM) | E | | | Y | |
| ORT CDBFR Interface Test Item 1 ($DP1CDB) | E | | | Y | |
| ORT DG Test Item 1 ($DP1DG) | E | | | Y | |
| ORT MHD Test Item 1 ($DP1MHD) | E | | | Y | |
| ORT MMD Test Item 1 ($DP1MMD) | E | | | Y | |
| ORT PFP Test Item 1 ($DP1PFP) | E | | | Y | |
| ORT PIT Test Item 1 ($DP1PIT) | E | | | Y | |
| ORT P/P Test Item 1 ($DP1PP) | E | | | Y | |
| ORT CPU Presence Test Item 2 ($DP2CDB) | E | | | Y | |
| ORT BSD PBIC Item 3 ($DP3BSD) | E | | | Y | |
| ORT FIFO Address Matrix Test Item 3 ($DP3FAM) | E | | | Y | |
| ORT MTU Test Item 3 ($DP3MTU) | E | | | Y | |
| ORT MTU Logging Test Item 3 ($DP3MTUL) | E | | | Y | |
| ORT PDR/Spa Logging Test Item 3 ($DP3PDR) | E | | | Y | |
| ORT RTIF Test Item 3 ($DP3RTI) | E | | | Y | |
| ORT TCG Test Item 3 ($DP3TCG) | E | | | Y | |
| ORT TCG Logging Test Item 3 ($DP3TCGL) | E | | | Y | |
| ORT TMDS Test Item 3 ($DP3TMD) | E | | | Y | |
| ORT VDA Test Item 3 ($DP3VDA) | E | | | Y | |
| ORT Bulk Disk Test Item 4 ($DP4BD) | E | | | Y | |
| ORT Bulk Tape Test Item 4 ($DP4BT) | E | | | Y | |
| ORT CRT Test Item 4 ($DP4CRT) | E | | | Y | |
| ORT Local Driver Item 4 ($DP4DRC) | E | | | Y | |
| ORT Flt.Point Option Plane Test Item 4 ($DP4FLT) | E | | | Y | |
| ORT Line Printer Test Item 4 ($DP4LPT) | E | | | Y | |
| ORT Standard Tape Test Item 4 ($DP4STT) | E | | | Y | |
| ORT Console Subsytem Test Item 5 ($DP5CON) | E | | | Y | |

| COMMAND DESCRIPTION | PORT | CP | SV | SA | UA |
|---|---|---|---|---|---|
| ORT P/P Subsytem Test Item 5 ($DP5PP) | E | | | Y | |
| ORT PDR/Spa Subsystem Test Item 5 ($DP5SPA) | E | | | Y | |
| ORT BSD PBIC Test ($DPBSD) | E | | | Y | |
| FIFO Bulk Disk Test ($DPFBDT) | E | | | Y | |
| ORT Master Driver ($DPLORT) | E | | | Y | |
| Display Memory (As Application Pgm) ($DPLYOC) | N | | | | |
| ORT Safing Test Monitor ($DPSAFE) | N | | | | |
| ORT Test Tape Routine ($DPTAPE) | N | | | | |
| Dump Memory (As Application Pgm) ($DUMPOC) | N | | | | |
| **GPC/GSE Create Tape Routine ($GPCGSE)** | | | | | |
| Goal Procedure Status ($GPST) | N | | | | |
| Goal System Status ($GSYS) | N | | | | |
| Inhibit (Level G Version) ($I) | N | | | | |
| CPRO LDB Analog Meas. Status ($L1) | D | | | | |
| CPRO LDB Analog Stimulus Status ($L2) | D | | | | |
| CPRO LDB Discrete Meas. Status ($L3) | D | | | | |
| CPRO LDB/UPLK Discrete Stimulus Status ($L4) | D | | | | |
| CPRO LDB Digital Pattern Meas. Status ($L5) | D | | | | |
| CPRO LDB/UPLK Digital Pattern Stimulus Status ($L6) | D | | | | |
| LDT Status ($LS) | D | | | | |
| 50 Kb Test S/W ($MCTPDM) | N | | | | |
| OC Time Crit. Patcher ($OCFTCP) | N | | | | |
| OCF Tester Dump ($OCFTST) | N | | | | |
| OCF Interface (OC Version) ($OCU) | N | | | | |
| Change Analog Trace ($PPCHTR) | Y | | | Y | |
| Print & Plot Compressed Data ($PPMLOT) | N | | | | |
| Remote Plot Request ($PPRDR) | Y | | | Y | |
| Select Maximum Channel Size ($PPSIZE) | Y | | | Y | |
| Process Plot Playback Data ($PSP) | E | | | Y | |
| Pseudo/System FD Status ($PSS) | D | | | | |
| PVO For Time Homogeneous Data Set ($PV) | D | | | | |
| LDB/UPLK Request ID Status ($R1) | D | | | | |
| Reference Designator Change ($REF) | D | | | | |
| CPRO Read Onboard Values ($ROV) | D | | | | |
| CPRO Analog Meas. Status ($S1) | D | | | | |
| CPRO Analog Stimulus Status ($S2) | D | | | | |
| CPRO Discrete Meas. Status ($S3) | D | | | | |
| CPRO Dbl Precision Analog Meas. Status ($S35) | D | | | | |
| CPRO Multiword Dig. Pattern Meas. Status ($S37) | D | | | | |
| CPRO GPC Floating Point Analog Meas. Status ($S38) | D | | | | |
| CPRO Data Set FD Status ($S39) | D | | | | |
| CPRO Discrete Stimulus Status ($S4) | D | | | | |
| CPRO Digital Pattern Meas. Status ($S5) | D | | | | |
| CPRO Digital Pattern Stimulus Status ($S6) | D | | | | |
| SPA Retrieval Utility ($SPAUTL) | N | | | | |
| BFL Retrieval ($SPBLOK) | Y | | | SDC | |
| File Card-Images To Cartridge Disk ($SPCARD) | N | | | | |
| Console Activity Trace ($SPCAT) | Y | | | SDC | |
| CITE POCC Interface Retrieval ($SPCPIR) | Y | | | SDC | |
| CTOC Retrieval ($SPCTOC) | Y | | | SDC | |
| Goal Language Trace ($SPGLT) | Y | | | SDC | |
| LDB/UPLK Command Retrieval ($SPLDUP) | Y | | | SDC | |

| COMMAND DESCRIPTION | PORT | CP | SV | SA | UA |
|---|---|---|---|---|---|
| Measurement & Command Retrieval ($SPMACR) | Y | | | SDC | |
| Compressed Data Point Retrieval ($SPMCDP) | N | | | | |
| Pwr Metering Compressed Data Retriev. ($SPMCDR) | N | | | | |
| Tape Compression ($SPMCPT) | N | | | | |
| Compressed Data Summary Retrieval ($SPMDSR) | N | | | | |
| Spooler (Print Data) Control ($SPOOL) | E | | | Y | |
| Operator Communications Retrieval ($SPOPCR) | Y | | | SDC | |
| **SPA Operating System Compare Utility ($SPOSCM)** | E | | | Y | |
| **Plot Spa Data ($SPP)** | E | | | Y | |
| **Pseudo FD Descriptor Restore ($SPPSDR)** | Y | | | Y | |
| Log Tape Raw Dump ($SPRAW) | Y | | | SDC | |
| Recovery Dump Retrieval ($SPRCVE) | Y | | | SDC | |
| Request Data Reduction ($SPRDR) | Y | | | Y | |
| Single Address Retrieval ($SPSAR) | Y | | | SDC | |
| Shuttle Memory Retrieval ($SPSMR) | Y | | | SDC | |
| Range Safety Retrieval ($SPRCSR) | Y | | | Y | |
| CDBFR Snapshot Retrieval ($SPSNPR) | N | | | | |
| Tape Status/Reset ($SPSTST) | N | | | | |
| Tape Reassignment ($SPTASW) | N | | | | |
| PDR Tape Copy ($SPTCOP) | N | | | | |
| Tape Copy Verify ($SPTCPV) | E | | | Y | |
| TCID Save/Restore ($SPTCSR) | N | | | | |
| TCID Save/Verify ($SPTCSV) | N | | | | |
| Task Status Program ($STAT) | Y | | Y | | Y |
| Status Goal Tables ($STGT) | N | | | | |
| Dump OC TWA Partition ($STTWAOC) | N | | | | |
| CPRO Msg Output For Invalid FD Type ($T3) | D | | | | |
| CPRO TMDS Discrete Stimulus Status ($T4) | D | | | | |
| CPRO Msg Output For Invalid FD's ($T5) | D | | | | |
| CPRO TMDS Dig. Pattern Status ($T6) | D | | | | |
| Dump Halted FEP ($UTFEPD) | N | | | | |
| Video Switch Utility ($UTVSWI) | N | | | | |
| CPRO Video Switch Set/Reset ($VSO) | N | | | | |
| CPRO Status Video Switch ($VSS) | N | | | | |
| CPRO Control Video Switch ($VSW) | N | | | | |
| Switch GPC/DIO modes (SWLDB) | New | | | | Y |

# Appendix D. — ACRONYMS

| | |
|---|---|
| | **- A -** |
| ACA | ADAS Command Application |
| ADAS | Advanced Data Acquisition System |
| AERO | Automated Electrical Retest Operations |
| ALS | Automated Logging System |
| AMRS | Automated Material Request System |
| ANSI | American National Standards Institute |
| AOS | Analog Overflow Signed |
| API | Application Program Interface |
| APU | Auxiliary Power Unit |
| ASM | Analog Serial Measurement |
| ATM | Asynchronous Transfer Mode |
| AWPS | Automated WAD Processing System |
| | **- B -** |
| B/U | Backup |
| BCD | Binary Coded Decimal |
| BFL | Block Funnel Logged |
| BIN | Business and Information Network |
| BTU | Bus Terminal Unit |
| | **- C -** |
| C&T | Communications and Tracking |
| CADS | Command and Data Simulator |
| CCC | Complex Control Center |
| CCMS | Checkout, Control, and Monitor System |
| CCP | Command and Control Processor |
| CCS | Complex Control Set |
| CDBFR | Common Data Buffer |
| CDT | Countdown Time |
| CEA | Common Equipment Area |
| CEU | Calibrated Engineering Units |
| CI | Configuration Item |
| CIE | Communications Interface Equipment |
| CITE | Cargo Integrated Test Equipment (Set) |
| CLCS | Checkout and Launch Control System |
| CM | Configuration Management |
| COLA | Collision Avoidance |
| COTS | Commercial Off the Shelf |
| CPDS | Computer Program Development Specifications |
| CPU | Central Processor Unit |
| CRMP | Command and Real-Time Monitor Position |
| CRT | Cathode Ray Tube |
| CS | Consolidated Systems |
| CSC | Computer Software Component |
| CSCI | Computer Software Configuration Item |
| CWLIS | Catenary Wire Lightning Instrumentation System |
| | **- D -** |
| DAP | Data analysis and Presentation |
| D/L | Downlink |
| DBSAFE | Data Bank Shuttle Automated Function Executive |
| DCN | Display and Control Network |
| DD | Data Dictionary |
| DDP | Data Distribution Processor |
| DFRC | Dryden Flight Research Center (Set) |
| DIO | Direct Input/Output |

| | |
|---|---|
| DLES | DPS LCC Expert System |
| DPS | Data Processing System |
| DSR | Display Synchronous Rate |
| | **- E -** |
| EDAMS | Engineering Data Access Management System |
| EDL | Engineering Development Laboratory |
| EIU | Engine Interface Unit |
| EU | Engineering Units |
| | **- F -** |
| FCAP | Facility Condition Assessment Program |
| FD | Function Designator |
| FDDI | Fiber Distributed Data Interface |
| FDID | Function Designator ID |
| FEP | Front End Processor |
| FOTE | Fiber Optic Terminal Equipment |
| FTP | File Transfer Protocol |
| FZ | Flow Zone |
| | **- G -** |
| GCP | Gateway Control Processor |
| GDB | Ground Data Bus |
| GMS | Ground Measurement System |
| GMT | Greenwich Mean Time |
| GOAL | Ground Operations Aerospace Language |
| GPC | General Purpose Computer |
| GSE | Ground Support Equipment |
| GUI | Graphical User Interface |
| G/W | Gateway |
| | **- H -** |
| HAZGAS | Hazardous Gas |
| HCI | Human Computer Interface |
| HGDS | Hazardous Gas Detection System |
| HIM | Hardware Interface Module |
| HMF | Hypergol Maintenance Facility (Set) |
| HOSC | Huntsville Operations Support Center |
| HUMS | Hydrogen Umbilical Mass Spectrometer |
| HWCI | Hardware Configuration Item |
| | **- I -** |
| IAPU | |
| IDE | Integrated Development Environment |
| IEEE | Institute of Electrical and Electronic Engineers |
| I/O | Input/Output |
| IP | Internet Protocol |
| IPR | Interim Problem Report |
| IRIG-B | Inter-Range Instrumentation Group |
| ISO | International Standards Organization |
| IVT | Interface Verification Testing |
| IWCS | Integrated Work Control System |
| | **- J -** |
| JSC | Johnson Space Center |
| | **- K -** |
| KATE | Knowledge-Based Autonomous Test Engineer |
| KATS | Kennedy Avionics Test Set |
| Kb | Kilo-bit |
| Kbs | Kilo-bits per second |
| KB | Kilo-Byte |
| KBS | Kilo-Bytes Second |

| | |
|---|---|
| KEDS | Kennedy Electric Drawing System |
| KSC | Kennedy Space Center |
| KSDN | Kennedy Switched Data Network |
| | **- L -** |
| LACD | Local Acquisition, Command, and Display Subsystem |
| LAN | Local Area Network |
| LATMOS | Lightning and Transients Monitoring System |
| LDBM | Launch Data Bus Monitor |
| LCC | Launch Control Center |
| LCC | Launch Commit Criteria |
| LCCX | |
| LDB | Launch Data Bus |
| $LO_2$ | Liquid Oxygen |
| LOC | Lines of Code |
| LON | LPS Operational Network |
| $LH_2$ | Liquid Hydrogen |
| LPS | Launch Processing System |
| LRU | Line Replaceable Unit |
| LS | Launch Sequence |
| LSDN | LPS Software Development Network |
| LTCMS | |
| LIVIS | Lightning Induced Voltage Instrumentation System |
| | **- M -** |
| Mb | Megabit |
| Mbs | Megabits per second |
| MB | Megabyte |
| MBS | Megabytes Second |
| MDM | Multiplexer/Demultiplexer |
| ME | Main Engine |
| MER | Mission Evaluation Room |
| MET | Mission Elapsed Time |
| MFR | Multi-function Room |
| MFSC | Marshall Space Flight Center |
| MICC | |
| MILA | Merritt Island Launch Area |
| MM | Mass Memory |
| MMU | Mass Memory Unit |
| MOIR | Mission Operations Integration Room |
| MSec | Millisecond |
| MTBF | Mean Time Between Failure |
| MTTR | Mean Time To Repair |
| MTU | Mission Timing Unit |
| | **- N -** |
| NASA | National Aeronautics and Space Administration |
| NFS | Network File System |
| | **- O -** |
| O&M | Operations and Maintenance |
| OCF | Orbiter Computational Facilities |
| OCR | Operations Control Room |
| OFI | Operational Flight Instrumentation |
| OIS | Operational Intercom System, also OI Standby (FEP) |
| OLDB | On Line Data Base |
| OLSA | Orbiter LPS Signal Adapter |
| OMI | Operations and Maintenance Instruction |
| OMRS | |
| OMRSD | |
| OMS | Orbital Maneuvering System |

| | |
|---|---|
| OPF | Orbiter Processing Facility |
| ORT | Operational Readiness Test |
| OTV | Operational Television |
| OV | Orbiter Vehicle |
| | **- P -** |
| PAMS | Portable Aft Mass Spectrometer |
| PCC | Processing Control Center |
| PCL | Prerequisite Control Logic |
| PCM | Pulse Coded Modulation |
| PCMMU | Pulse Coded Modulation Master Unit |
| pF | Pico-Farad |
| PFP | Programmable Function Panel |
| PLC | Programmable Logic Controller |
| PMS | Permanent Measurements System |
| POST | Power on Self Test |
| PRACA | Problem Reporting and Corrective Action |
| PSCNI | Program Support Communications Network Internet |
| | **- Q -** |
| | **- R -** |
| RADS | Remote Acquisition and Display Subsystem |
| RAID | Redundant Array of Inexpensive Disks |
| RCS | Reaction Control System |
| RCVS | Remote Controlled Video Switch?? |
| RNET | Reconfiguration Network |
| RON | Restricted Operational Network |
| RSYS | Responsible System |
| RTCN | Real-Time Critical Network |
| RTPS | Real-Time Processing System |
| | **- S -** |
| SACS | Systems Software Avionics Command Support |
| SAIL | Shuttle Avionics Integration Lab (Set) |
| SBC | Single Board Computer |
| SCA | Sequence Control Assembly |
| SCAN | Shuttle Configuration Analysis Network |
| SCID | System Configuration Item |
| SCSI | Small Computer System Interface |
| SCT | System Configuration Table |
| SDC | Shuttle Data Center |
| SDE | Satellite Development Environment |
| SDS | Shuttle Data Stream |
| SDT | Shuttle Data Tape |
| SECAS | Shuttle Engineering Computer Application System |
| SGOS | Shuttle Ground Operations Simulator |
| SIM | Simulation System |
| SIMS | Still Image Management System |
| SL | Space Lab |
| SLOC | Source Lines of Code |
| SL-GMS | Sherrill-Lubinski-Graphical Modeling System |
| SLP | SSME Load Program |
| SLS | System Level Specification |
| SLWT | Super Light Weight Tank |
| SODN | Shuttle Operations Data Network |
| SONET | Synchronous Optical Network |
| SPDMS | Shuttle Processing Data Management System |
| SPF | Software Production Facility |
| SRB | Solid Rocket Booster |
| SSC | Stennis Space Center |

| | |
|---|---|
| SSME | Space Shuttle Main Engine |
| SSPF | Space Station Processing Facility |
| SSR | System Synchronous Rate |
| STM | Synchronous Transfer Mode |
| | **- T -** |
| TAB | TACAN Bearing (SDT Type) |
| TACAN | Tactical Air Navigation |
| TBD | To Be Defined |
| TCID | Test Control Identifier |
| TCMS | |
| TCP | Transmission Control Protocol |
| TCS | Test Control Supervisor |
| TCS-1 | Test Control Supervisor - Single Command |
| TCS-S | Test Control Supervisor - Test Sequences |
| TDM | Time Division Multiplexing |
| TEI | Test End Item |
| THDS | Time Homogenous Data Set |
| | **- U -** |
| UDP | |
| UOPS | Utility Outage Processing System |
| USCA | Universal Signal Conditioning Amplifier |
| UTC | Universal Time Coordinated |
| | **- V -** |
| V&DA | |
| VAB | Vehicle Assembly Building |
| VHMS | Vehicle Health Management System |
| VME | |
| VP | Vehicle Processing (Set) |
| VPF | Vertical Processing Facility |
| VSI | Video Simulation Interface |
| VTP | VME Telemetry Processor |
| | **- W -** |
| WAN | Wide Area Network |
| W/S | Workstation |
| | **- X - Z -** |